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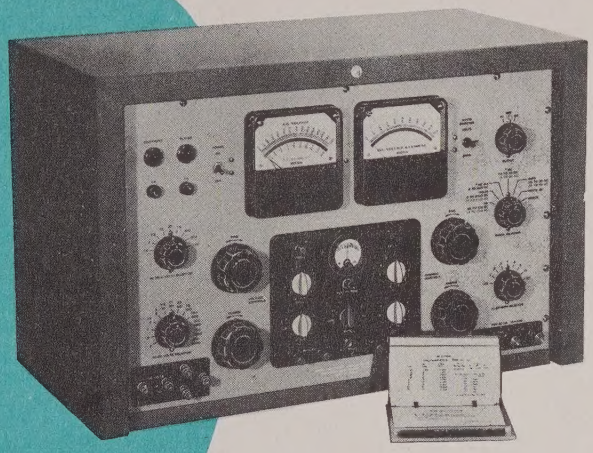
Manual of Instructions

Model 829



AC-DC Instrument Calibration Standards

Model 829A

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

829 A

Foreword

The Models 829 and 829A AC-DC Instrument Calibration Standards are the most widely used, self-contained instrument standards in the United States. They employ the finest components available and are designed to save you time and motion whenever you need to check or calibrate an electrical instrument.

You don't have to be a technician to operate this equipment, nor even know how or why an electrical instrument works. The step-by-step operational procedure has been refined to a minimum. A system of interlocks prevents damage to the meter you're testing, as well as the standard meters, should you twist the wrong control.

The instruction book describes the equipment in detail, and we hope you take time to read it, but it's not necessary for constant reference. The mechanical Autodex reference index is for your daily use or as a refresher if you forget. Every calibration step is summarized for each type and range of instrument.

This equipment was designed to make your calibration work easier, faster and more convenient. It offers laboratory accuracy but is built for every day use, anywhere in your plant.

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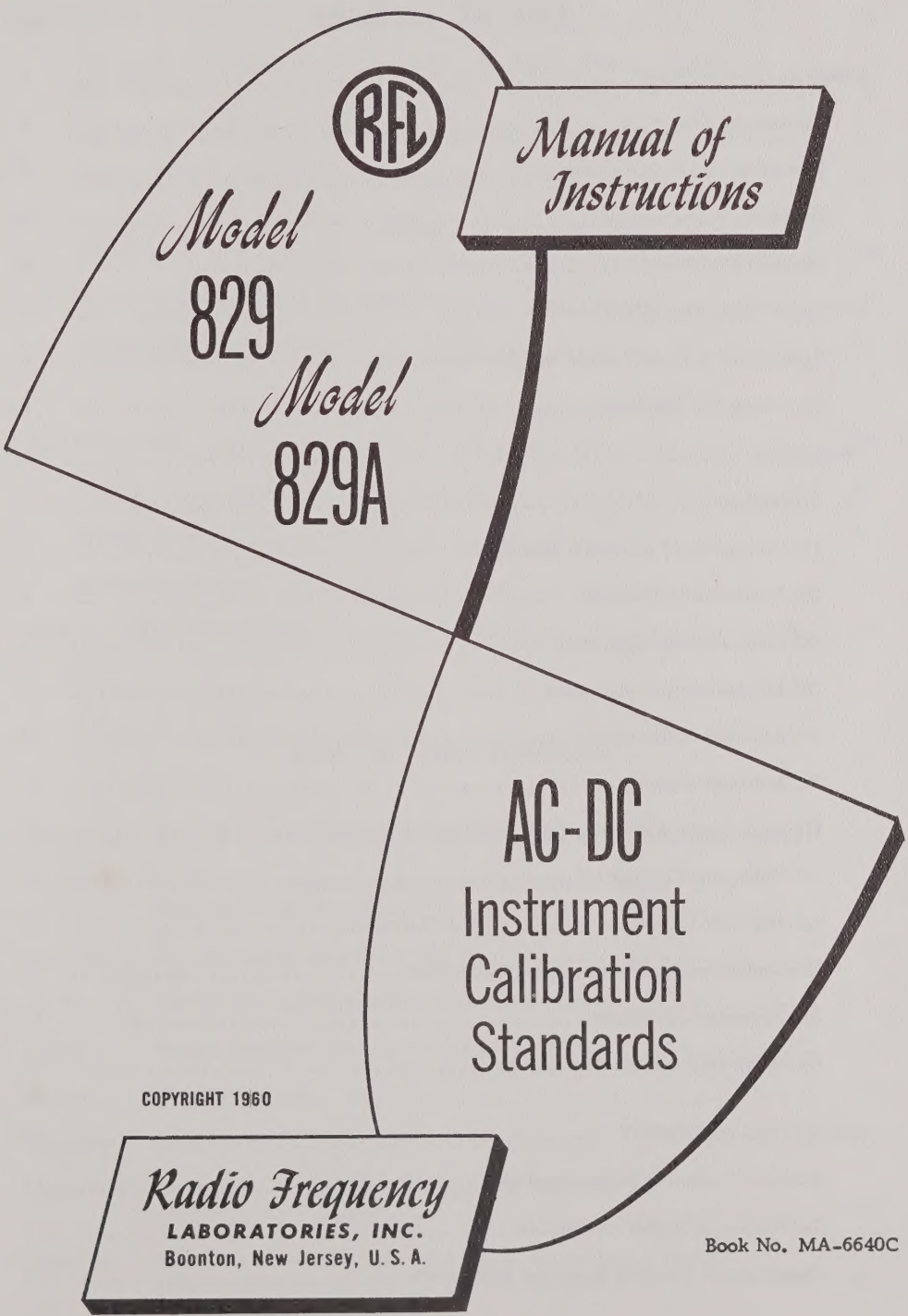

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Book No. MA-6640C

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WARNING

Operation of this equipment involves the use of high voltages which are dangerous to life. Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside the equipment with voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors, etc. To avoid casualties always discharge and ground circuits prior to touching them.

Model 829

Model 829A

AC–DC
INSTRUMENT
CALIBRATION
STANDARDS

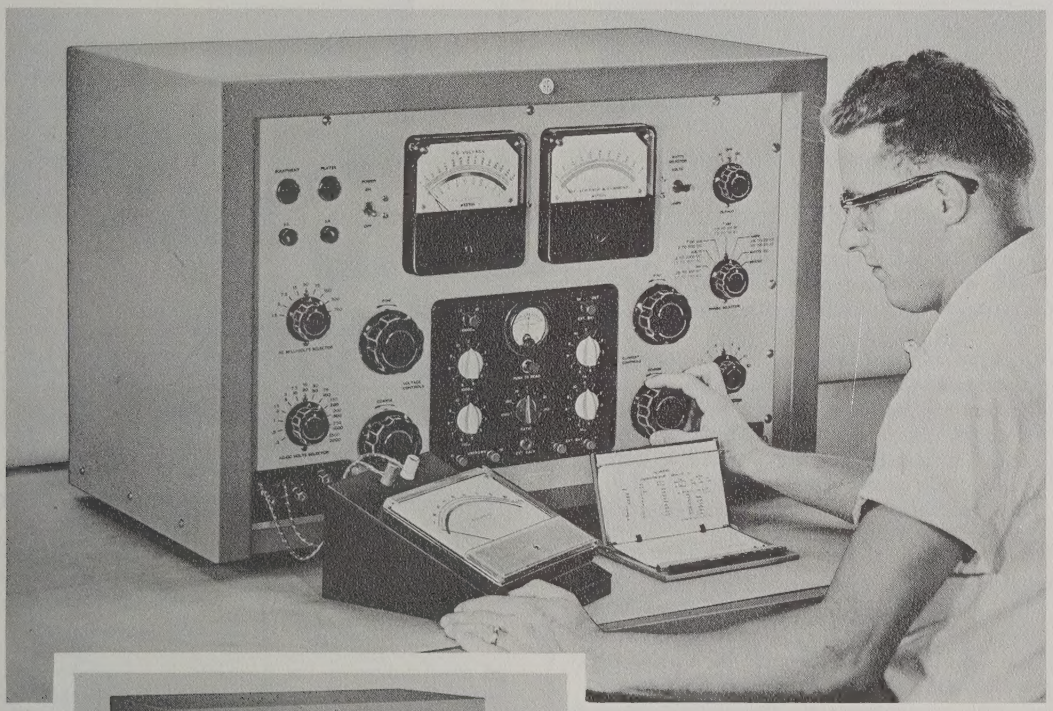


Figure 1A. Typical Bench Set-up for Calibrating Meters with Model 829.

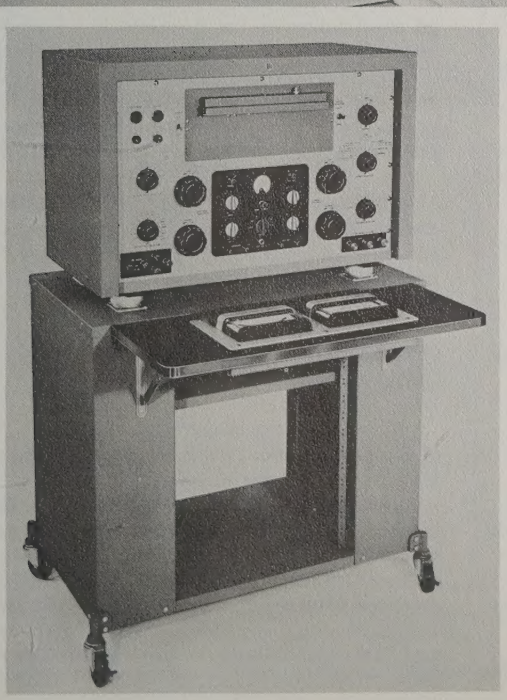


Figure 1B. Model 829A Mounted on Model 10 Cart with Horizontal Standard Meters Recessed in Drop-leaf Work Counter.

Description

GENERAL

The Models 829 and 829A AC-DC Instrument Calibration Standards are electrically identical and physically differ in only two respects: the Model 829A employs separately housed, horizontally mounted standard meters, and a light is provided on its front panel in place of the vertically mounted standard meters in the Model 829. The prime difference between both models is calibration accuracy. The Model 829 has a direct reading accuracy of $\pm 1\%$ and $\pm 0.5\%$ using correction factors supplied in the push-button, mechanical index; the direct reading accuracy of the Model 829A is $\pm 0.5\%$ and $\pm 0.25\%$ using the correction factors.

Both units consist of wide range AC and DC voltage and current sources, control elements, safety interlocks, and two standard instruments for measuring accurately the magnitude of AC or DC current and voltage that is being applied to an instrument under calibration. A Wheatstone bridge is included for instrument repair work.

To protect the standard instruments and controls, the front panel is recessed into the aluminum cabinet. Adequate ventilation is provided at the rear. Two wood rails underneath the chassis provide ample, safe finger clearance for two men to lift the unit. If it is to be used in different plant areas or frequently transported, the Model 10 Test Equipment Cart with drop-leaf work shelf (shown in Figure 1B) is recommended

Electrical connections to the instrument under calibration are made at the terminal posts at the lower right and left sides of the front panel. The FINE and COARSE Variacs on the right of the panel control the current output, and the FINE and COARSE Variacs on the left side of the panel control the voltage output. All AC functions are marked in red, DC in black.

The equipment will calibrate DC voltage instruments between 0.25×10^{-3} and 2,000 volts full-scale, DC current instruments between 2×10^{-6} and 20 amperes, AC voltage instruments between 1.5×10^{-3} and 1,500 volts, and AC current instruments between 1.5×10^{-3} and 20 amperes. Since the DC voltage and DC current sections are separate and complete, this equipment may also be used to calibrate electrodynamic wattmeters by the DC method. The equipment is designed to supply the burdens of standard commercial instruments. The calibration ranges and burdens are given in Table 1.

CALIBRATION CHARTS

Before shipment, the full-scale output on each range is measured on basic standards with recent Bureau of Standards calibration certificates. These readings are made to an accuracy of $\pm 0.1\%$ and are recorded on a push-button file mechanism. A brief operational procedure is included with the calibration chart for each type of instrument. Figure 2 shows this file open for use. The calibration figures recorded are the actual voltage or current outputs

Figure 2. Autodex Calibration Chart File.

when the standard instruments of either the Model 829 or 829A read exactly on the full-scale mark. A scale distribution correction chart is used to obtain the greatest possible accuracy at major down-scale marks. AC calibrations are made at 50, 60 and 400 cps.

PROTECTIVE AND SAFETY FEATURES

Instruments under test are protected against accidental overload by means of interlocks which disconnect the internal supply when range settings are changed without first returning the magnitude variable auto-transformer to zero. After interlocks have been tripped, it is necessary to return the magnitude controls to zero to reconnect the power supply to the instrument.

Resistance in the current circuits prevents excessive overloading of the standard instrument or the instrument being tested. Voltage divider circuits are designed for a maximum no-load to full-load variation of 2 to 1.

OPERATING CHARACTERISTICS

The frequency of the output on the AC ranges is that of the power source. The frequency of the power source may be in the range of 50 to 400 cps. The nominal line voltage should be 115 volts ($\pm 10\%$) with a short time stability of $\pm 1\%$, or better than the accuracy to which measurements are to be made. This stability is normally obtained on lightly loaded 115-volt, 60-cps lines. Where lines are loaded and unstable, it may be necessary to supply the equipment from a Model 500S Sorensen regulator. This combination is most satisfactory where 60-cycle output is all that is desired.

For calibration frequencies at other than line frequency, a variable frequency power supply can be used. This power supply should have low harmonic distortion and good voltage regulation. At full continuous load, both Models 829 and 829A draw current at various frequencies as follows:

Input Freq.	Cal. Output	Current
50-400 cps	AC	0.75 amp.
50 cps	DC	2.8 amp.
60-400 cps	DC	1.5 amp.

The VA output requirements for the power supply can be calculated for whatever calibration conditions that may be desired by multiplying current listed by 115 volts.

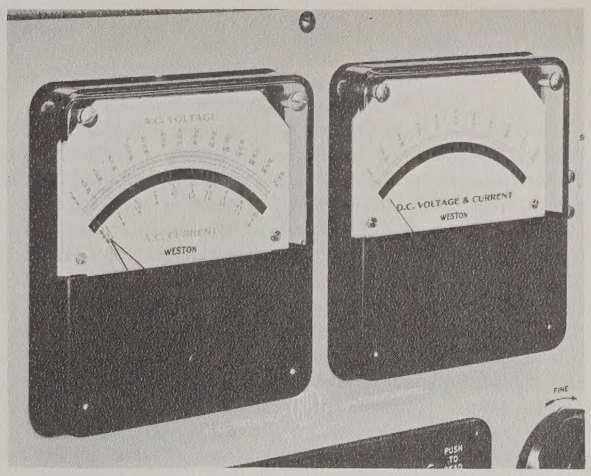


Figure 3. Weston Standard Instruments used in Model 829.

Table I. Calibration Ranges

AC VOLTAGE

MILLIVOLTS	MAX. CURRENT	VOLTS	MAX. CURRENT
1.5	5 uA	1.5	1.6 Amp.
3.0	5	3.0	2.0
7.5	5	7.5	1.0
15.0	5	15.0	0.5
30.0	5	30.0	0.2
75.0	5	75.0	0.15
150.0	5	150.0	0.09
300.0	5	300.0	0.08
750.0	5	750.0	0.02
		1500.0	0.02

DC VOLTAGE

MILLIVOLTS	MAX. CURRENT	VOLTS	MAX. CURRENT
0.25	.00013 Amp.	0.2	.030 Amp.
0.5	.0003	0.5	.030
1.0	.0005	1.0	.030
2.5	.0013	2.0	.030
5.0	.0025	5.0	.030
10.0	.005	10.0	.030
25.0	.013	20.0	.030
50.0	.025	50.0	.020
100.0	.05	100.0	.020
		200.0	.020
		500.0	.020
		1000.0	.020
		2000.0	.020

AC CURRENT

MILLIAMPERES	MAX. RESISTANCE
1.5	10,000 ohms
3.0	10,000
7.5	10,000
15.0	10,000
30.0	10,000

AMPERES	MAX. BURDEN
0.05	4.0 VA
0.10	8.0
0.20	15.0
0.50	15.0
1.0	15.0
2.0	15.0
5.0	15.0
10.0	30.0
20.0	40.0

DC CURRENT

MICROAMPERES	MAX. RESISTANCE
2	20,000 ohms
5	20,000
10	20,000
20	20,000
50	20,000
100	20,000
200	20,000
500	20,000

MILLIAMPERES	
1	10,000
2	10,000
5	10,000
10	10,000
20	10,000

AMPERES	MAX. BURDEN
0.05	0.2 VA
0.10	0.5
0.20	1.0
0.50	2.0
1.0	4.0
2.0	7.0
5.0	15.0
10.0	45.0
20.0	50.0

WATTMETERS are calibrated by the DC method. The maximum potential and current coil ratings are as listed above under DC voltage and DC current.

STANDARD
INSTRUMENTS

Model 829: Both instruments were designed by the Weston Electrical Instrument Corporation for vertical use. The DC standard is a basic 1-milliampere movement built into a Weston Model 921 frame. A hand-marked, 5-inch mirror scale and knife edge pointer permit accurate readings. The scale is marked with a 100-division scale with figures for 20, 50, and 100 full-scale units. The AC standard is a 100-milliampere movement adjusted for 75 volts full-scale with a series resistor built into a Weston Model 924 frame. A third binding post is provided to permit direct connection across the coils for use with the current transformer. Hand-marked mirror scale and knife edge pointer permit accurate readings. A double scale of 100 and 150 divisions is marked 2, 5, 10 for AC current and 30, 75, 150 for AC volts. Multiplication factors of ten are used for the ranges not marked.

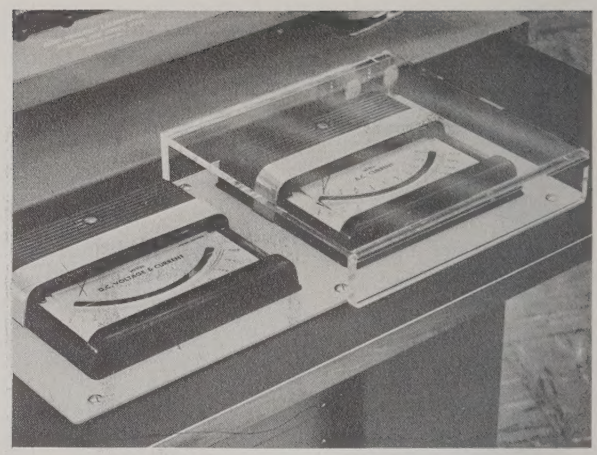


Figure 4
Weston Standard Instruments used in Model 829A.

Model 829A: Both instruments are mounted horizontally in an external box as shown in Figure 4. These meters have a reproducibility of better than 1/4 of 1%. The hand-drawn mirrored scales are reversed so that the scales are nearest the operator. The meters may be either of Weston-Daystrom or Sensitive Research Instrument manufacture as ordered. When Weston instruments are supplied, the DC meter is the Model 901 and the AC meter is the Model 904 with 5-1/2" scales. When Sensitive Research instruments are supplied, the DC meter is the Model N and the AC meter is the Model NSI with 6" scales. The sensitivity and scale division of the horizontal meters are identical to the vertical meters of the Model 829.

Installation and Adjustment

UNPACKING THE
EQUIPMENT

Carefully remove the external wood protecting cover, then cut the moisture barrier exposing the equipment. Inspect the unit for damage in shipment. Tighten any loose screws and nuts. The top cover of the equipment can be taken off by removing three Phillips head screws on each side, and five Phillips head screws around the front panel, and one at the lower center of the back. Inspect the internal parts for possible shipping damage. Replace cover, connect to 115-volt, 60-cps line, turn ON and operate briefly over each range position as explained under OPERATION. Return postpaid quality control card with appropriate notations.

CONNECTION TO POWER
SOURCE AND GROUND

Plug the line cord plug into a 115-volt, 60-cycle line receptacle. The third blade grounds the cabinet to the AC power system ground.

If the equipment is to be operated from a variable frequency power oscillator, the line cord is plugged or connected into the power supply, making sure that the AC ground connection is completed through the variable frequency power supply. The fuses F-103 and F-104 are mounted on the rear panel and protect internal measuring circuits. The 3-ampere fuses F-101 and F-102 are mounted on the front panel and are the EQUIPMENT fuses on the AC line.

Figure 5. Terminal Panel.

Figure 5 shows a view of the rear panel and the external meter jack J-101; Model 829's are shipped with a shorting plug in this jack as illustrated above. With Model 829A's, the connecting cable from the horizontal standard meter assembly is plugged into this jack.

Operation

PRECAUTIONS

Although many safeguards against destroying the instrument being calibrated have been constructed into this equipment, it is possible that trouble may be encountered due to faulty operation. The following precautions must be taken:

a. Do not bypass interlocks except as required for periods of repair.

b. Keep in mind that the standard instruments, precision shunt, and multipliers in the equipment are delicate in nature and are designed to give a high degree of accuracy for long periods if treated with care.

c. Turn all magnitude (VOLTAGE or CURRENT) Variac controls entirely counter-clockwise before turning off the source. All SELECTOR switches and the OUTPUT switch have been provided with protective interlocks. Before proceeding with the calibration of other ranges, the VOLTAGE and CURRENT COARSE CONTROLS must be turned to full counter-clockwise position.

d. Do not remove the instrument being calibrated while energized. Always return all instruments to zero before continuing.

e. Check all connections and control switch positions before energizing a circuit.

f. In operation, the equipment is held to value and the instrument being calibrated is read. Figure 6 shows a front view of the control panel.

g. The range indicated by the SELECTOR is represented by a full-scale deflection of the standard. To determine the value of the output voltage or current, utilize the scale figures whose full-scale value when divided or multiplied by multiples of 10 result in the value indicated by the SELECTOR. The value indicated on the standard when multiplied or divided by the same multiple of 10 is equal to the output voltage or current.

Before calibrating any meters, make sure the standard instrument pointers are on zero. Mechanical adjustment can be made with the small screw on the front of the instrument case; tap the instrument lightly while making this adjustment.

DETERMINATION OF
DC METER RESISTANCE

If the DC resistance of the instrument is unknown but is required for its calibration, connect the instrument to AC-DC MA terminals. Turn POWER switch to ON. Set RANGE SELECTOR to MA position. Set bridge decade for 0 ohms. Set OUTPUT switch for DC. Beginning at the lowest AC-DC VOLTS SELECTOR value, operate VOLTAGE CONTROLS and apply enough voltage to bring the instrument under test to full-scale. Increase the decade resistance (white knobs), while holding the voltage constant, until half-scale is indicated on the test instrument. The resistance indicated on the decade dials is equal to the resistance or impedance of the instrument under test.

DC VOLTMETER
CALIBRATION

The following procedure should be adhered to in setting up DC voltmeter calibration:

a. Check to see that the CURRENT and VOLTAGE CONTROLS are at zero (maximum counter-clockwise position) and turn POWER switch to ON. The EQUIPMENT pilot lamp turns on immediately; the PLATES pilot lamp has a 30-second delay.

Table 2.
Voltages for Microampere Ranges.

CURRENT	VOLTAGE
2 μA	0.2 Volts
5	0.5
20	2.0
50	5.0
200	20.0
500	50.0

Table 3.
Voltages for Milliampere Ranges.

CURRENT	VOLTAGE
1 MA	10 Volts
2	20
5	50
10	100
20	200

Table 4.
Voltages for Millivolt Ranges.

CURRENT	VOLTAGE
0.05 Amp	0.25 MV
0.1	0.5
0.2	1.0
0.5	2.5
1.0	5.0
2.0	10.0
5.0	25.0
10.0	50.0
20.0	100.0

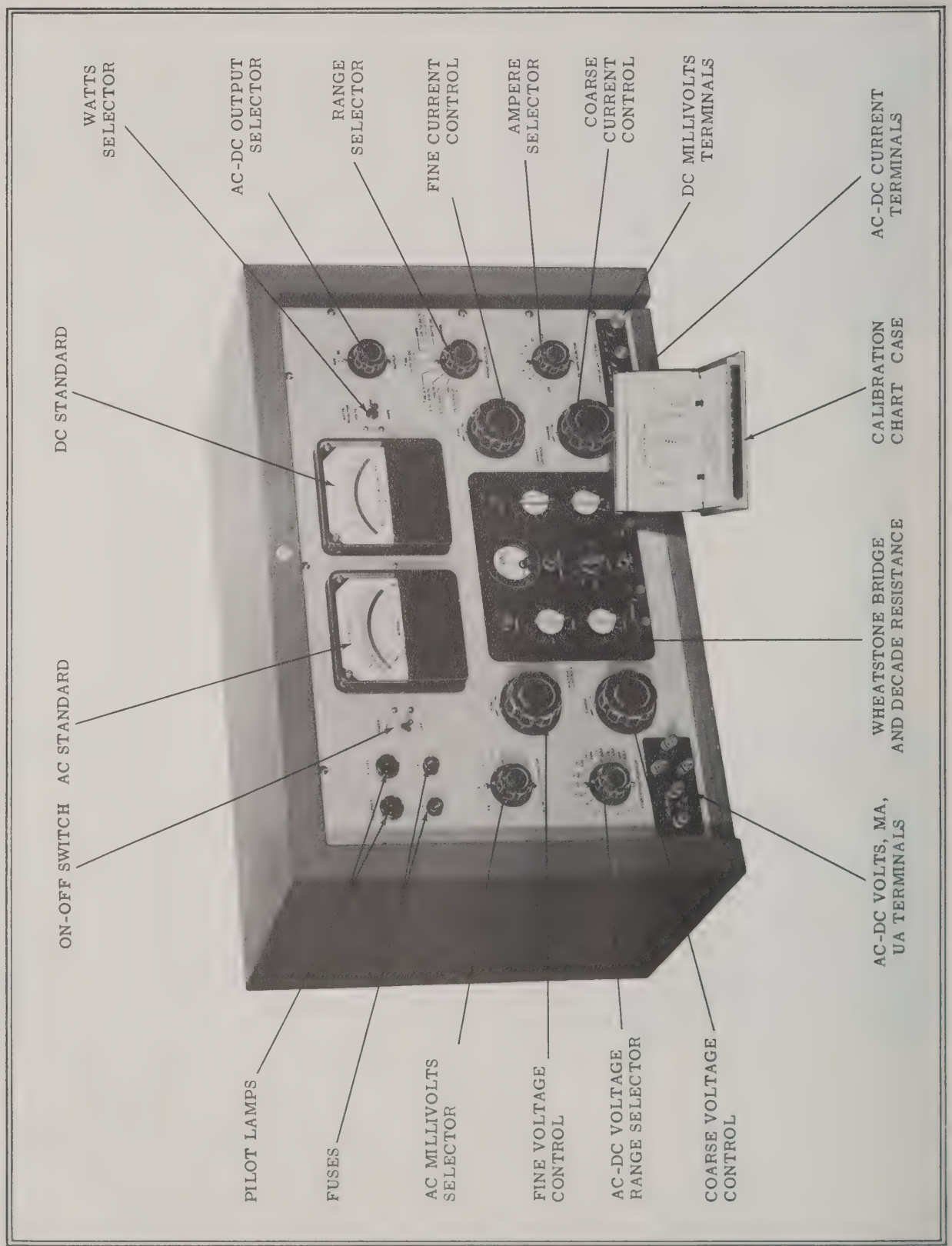


Figure 6. Front View of Control Panel.

b. Set RANGE SELECTOR to VOLTS (.2 to 2000 DC).

c. Set AC-DC VOLTS SELECTOR to desired range.

d. Connect instrument under calibration to AC-DC VOLTS terminals.

e. Set OUTPUT switch to DC.

f. Operate the VOLTAGE CONTROLS. Read DC standard.

DC MICROAMMETER
CALIBRATION

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to DC μA (2 to 500 DC).

c. Set AC-DC VOLTS SELECTOR to voltage indicated in Table 2.

d. Connect instrument under calibration to DC μA terminals.

e. Set decade resistance (white knobs) so that the total resistance of the instrument under calibration plus decade equals 20,000 ohms. (The total circuit resistance is 100,000 ohms for DC μA. (See Figure 10.)

f. Set OUTPUT switch to DC.

g. Operate VOLTAGE CONTROLS. Read DC standard.

DC MILLIAMMETER
CALIBRATION

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to MA (1.0 to 20 DC).

c. Set AC-DC VOLTS SELECTOR to voltage indicated in Table 3.

d. Connect instrument under calibration to AC-DC MA terminals.

e. Set decade resistance (white knobs) so that the total resistance of the instrument under calibration plus decade equals 10,000 ohms.

f. Set OUTPUT switch to DC.

g. Operate VOLTAGE CONTROLS. Read DC standard.

DC AMMETER
CALIBRATION

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to AMPS (.05 to 20 DC).

c. Set AC-DC AMPS SELECTOR to desired range.

d. Connect instrument under calibration to AC-DC AMPS terminals.

e. Set OUTPUT switch to DC.

f. Operate CURRENT CONTROLS. Read DC standard.

DC MILLIVOLT
RANGE

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to MV.

c. Set AC-DC AMPS SELECTOR to current indicated in Table 4.

d. Connect instrument under calibration to DC MV terminals.

e. Set OUTPUT switch to DC.

f. Operate CURRENT CONTROLS. Read DC standard.

ELECTRODYNAMIC WATTMETER
CALIBRATION BY DC METHOD

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to WATTS DC.

c. Set OUTPUT switch to DC.

d. Set AC-DC AMPS SELECTOR and AC-DC VOLTS SELECTOR to desired voltage and current ranges.

e. Connect wattmeter potential and current coils to AC-DC VOLTS and AC-DC AMPS terminals respectively, observing polarity.

f. Alternately place WATTS SELECTOR in VOLTS and AMPS position and operate VOLTAGE and CURRENT CONTROLS until desired range value is indicated on the DC standard in each case.

g. The product of VOLTS x AMPS = WATTS.

h. For greater accuracy, reverse potential and current leads and repeat procedure. Take the average of the two readings.

AC VOLTMETER
CALIBRATION

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to VOLTS (1.5 to 1500 AC).

c. Set AC-DC VOLTS SELECTOR to desired range.

d. Connect instrument under calibration to AC-DC VOLTS terminals. For 1.5 and 3.0-volt instruments with large current requirements, use the G terminal and the 1.5 or 3.0-volt terminal.

e. Set OUTPUT switch to AC.

f. Operate VOLTAGE CONTROLS. Read AC standard.

AC MILLIVOLT CALIBRATION
(VACUUM TUBE VOLTMETERS)

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to MV (1.5 to 750 AC).

c. Set AC MILLIVOLTS SELECTOR to desired range.

d. Connect instrument under calibration to AC MV terminals.

e. Set OUTPUT switch to AC.

f. Operate VOLTAGE CONTROLS. Read AC standard.

NON-INDUCTIVE
AC MILLIAMMETER CALIBRATION

(See Page 15 for Inductive AC Milliammeters.)

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to MA (1.5 to 30 AC).

c. Set AC-DC VOLTS SELECTOR as indicated below.

d. Set decade resistance (white knobs) so that impedance of instrument under calibration plus decade equals 10,000 ohms.

e. Connect instrument under calibration to AC-DC MA terminals.

f. Set OUTPUT switch to AC.

g. Operate VOLTAGE CONTROLS. Read AC standard.

Table 5.
Voltages for AC Milliampere Ranges.

CURRENT	AC VOLTAGE
1.5 MA	15
3.0	30
7.5	75
15.0	150
30.0	300

AC AMMETER
CALIBRATION

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to AMPS (.05 to 20 AC).

c. Set AC-DC AMPS SELECTOR to desired range.

d. Connect instrument under calibration to AC-DC AMPS terminals.

e. Set OUTPUT switch to AC.

f. Operate CURRENT CONTROLS. Read AC standard.

OPERATION OF THE
WHEATSTONE BRIDGE

a. Turn POWER switch to ON.

b. Set RANGE SELECTOR to BRIDGE position.

c. Turn EXT. BAT. switch to OUT position.

d. Set RATIO switch for desired multiplier.

e. Set decade (white knobs) to approximate resistance of the unknown.

f. Set OUTPUT SELECTOR to DC.

g. Depress PUSH TO READ switch and vary decade until 0 is indicated on the null indicator.

h. Decade setting x multiplier = unknown resistance.

i. For greater sensitivity for resistance values of 50,000 ohms and up, turn EXT. BAT. switch to IN position and connect jumpers between AC-DC VOLTS terminals and the bridge EXT. BAT. terminals, observing polarity. Follow procedure as outlined for DC voltmeter calibrations and apply the following voltages to the bridge:

RESISTANCE	VOLTAGE
50K to 2 megohms	20 V DC
2 to 4	50
4 to 10	100
10 to 11	200

Supporting Equipment

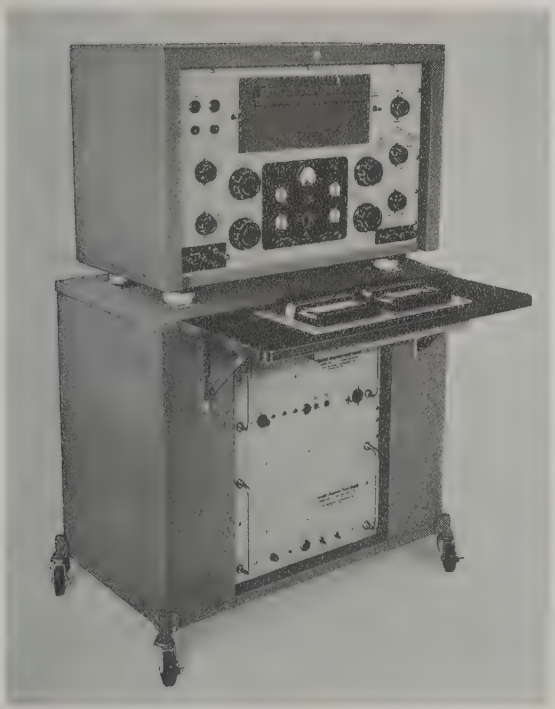


Figure 7. Model 829A, Model 10 Cart and Model 500 Variable Frequency Power Supply.

VARIABLE FREQUENCY POWER SUPPLIES

Where calibration of AC meters at other than line frequency is desired, the Model 829/829A must be driven by a suitable power supply, choice of which will depend on how good the line source is with regard to voltage stability and harmonic distortion and what frequency or frequencies are desired for calibration purposes. At 50 cps input the Models 829 and 829A demand about 325 VA for maximum DC output and at 400 cps input approximately 150 VA for maximum DC output. For AC output the demand is about 90 VA from 50 to 400 cps. While any supply having suitable characteristics can be used, if a new purchase is contemplated, consideration of the RFL Model 150, 250 or Model 500 Variable Frequency Power Supplies is recommended. All units are designed to accept plug-in oscillators and fit conveniently into the Model 10 Cart for an integrated, mobile instrument calibration system as shown in Figure 7.

CALIBRATION AT HIGHER ACCURACIES

The Model 829 or 829A can be used as a control source for the Model 1605 AC-DC Calibration/Transfer Standard to calibrate instruments having greater accuracy requirements than supplied by either the 829 or 829A alone. The Model 1605 can also be used to calibrate either model. The 829/829A combination with the 1605 has a calibrated accuracy of $\pm$0.03% for DC voltages and currents and $\pm$0.05% for $\overline{\text{AC}}$ voltages and currents over all ranges from $\overline{\text{DC}}$ to 400 cps. This combination is illustrated in Figure 8.

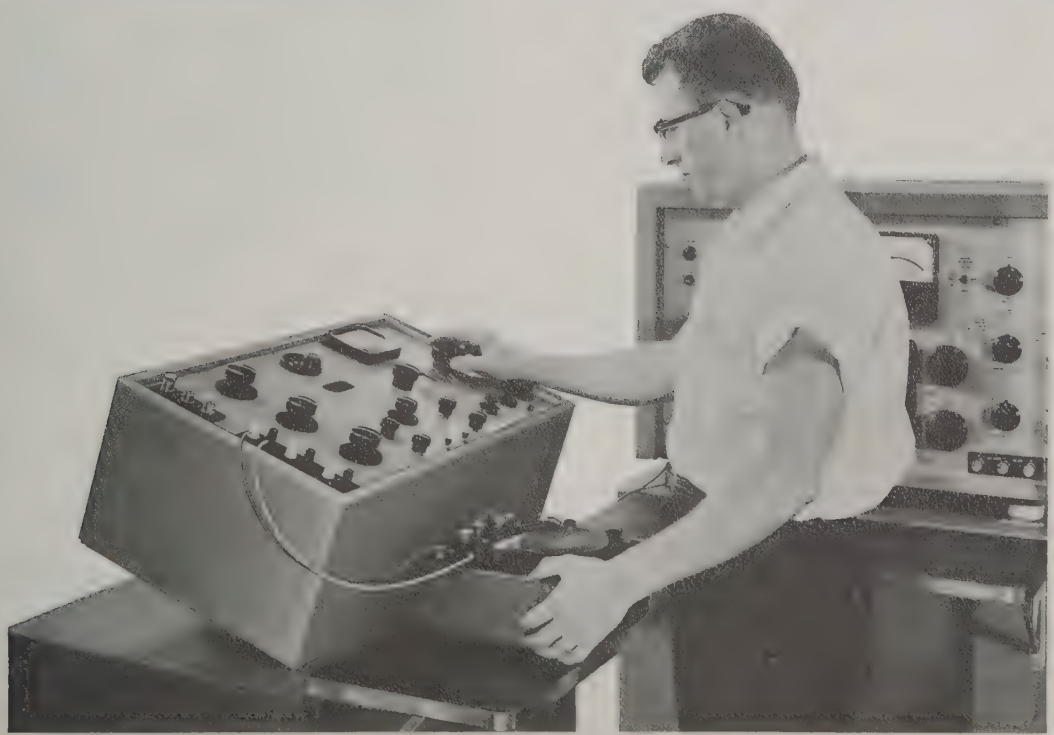


Figure 8. Using the Model 829 as a Power Source for the Model 1605 to Calibrate Meters.

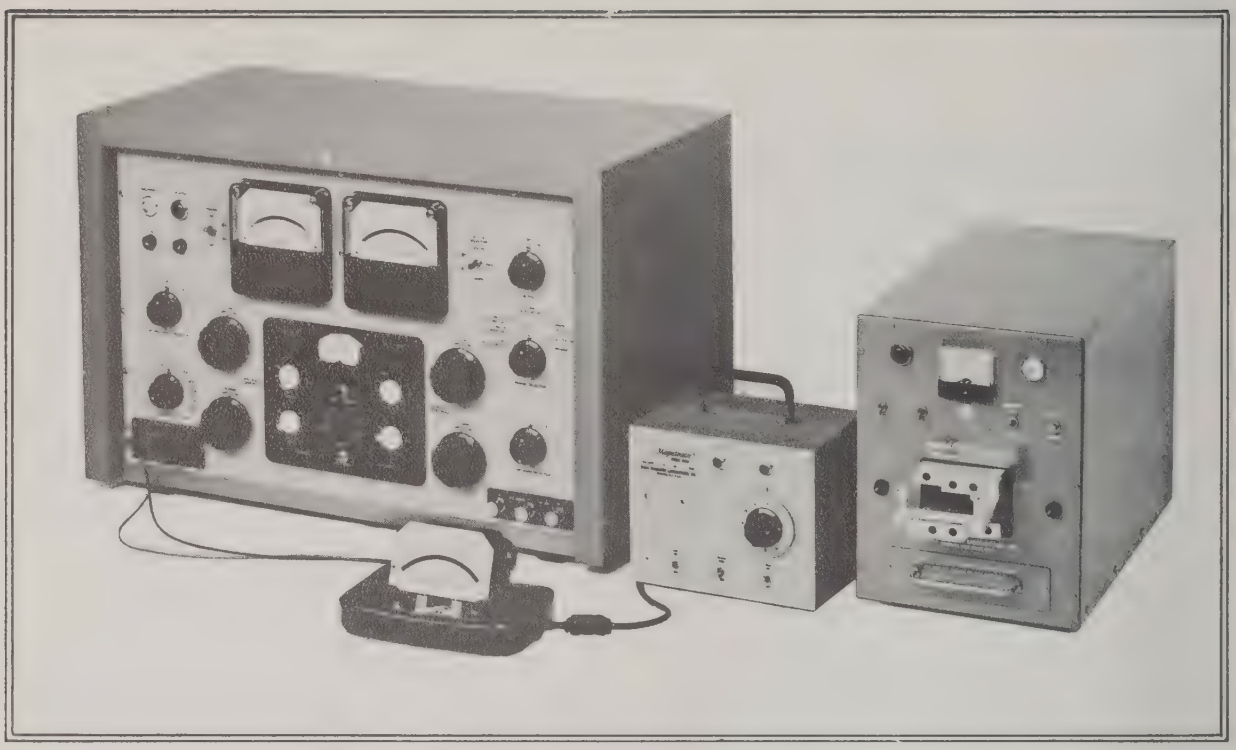


Figure 9. Typical Set-up for Charging, Treating and Calibrating Electrical Instruments.

CHARGING AND TREATING ELECTRICAL INSTRUMENTS

After repairing an electrical instrument and particularly after disassembly of the magnet structure, it is usually necessary to recharge and treat the magnet. A complete system for charging, treating and calibrating is shown in Figure 9.

The Model 1500 Magnet Charger will saturate any type of instrument employing a magnetic circuit and operates on the condenser discharge principle. After the magnet has been charged, it is placed in the appropriate treating coil or fixture of the Model 889A Magnetreater and its leads connected to the proper output terminals of the Model 829/829A, which is then adjusted to produce proper full-scale current or voltage. The instrument magnet is then precisely brought down to top mark reading by adjustment of the Model 889A controls. This controlled demagnetization or treating is accomplished by pulsing DC under full control of the operator at all times and is the desirable method for stabilizing any type of permanent magnet. It is particularly valuable for treating core type magnets (shielded circuits) where the older AC coil method requires unusually high currents and skilled operator techniques.

Theory of Operation

CIRCUITS FOR CALIBRATION OF DC VOLTMETERS, DC MILLIAMMETERS AND DC MICROAMMETERS

The DC voltage circuit is set up by switches and includes a variable one-half wave power supply, voltage dividing networks, a standard DC instrument, and precision multiplier resistors. Figure 10 shows the general arrangement of the circuit parts.

The FINE and COARSE Variacs control the voltage on the primary of the potential transformer and, therefore, the output DC voltage. The AC-DC VOLTS SELECTOR connects the required tap on the potential transformer, selects the voltage dividing networks, and determines the instrument multiplier for the desired voltage range. The OUTPUT switch connects the voltage supply directly to the AC-DC VOLTS terminals when the RANGE SELECTOR is set to VOLTS. For DC microamperes, the 20,000-ohm decade resistor and the 80,000-ohm fixed resistor are connected into the circuit. With the decade resistor enough resistance is added to make the total circuit resistance, including the instrument under test and the 80,000-ohm fixed resistor, equal to 100,000 ohms. The microampere output for each range is calculated by dividing the voltage indicated by 100,000. For DC milliammeters only the 10,000-ohm decade resistor is used in the circuit, and the calculations are based on the 10,000-ohm value.

CIRCUITS FOR CALIBRATION OF DC AMMETER AND DC MILLIVOLTMETER

The current circuit uses a variable full-wave current supply, current limiting resistors, a precision shunt, and the DC standard meter. The functional diagram of Figure 11 shows the electrical arrangement of the components. The output AC ripple at full-scale is less than +2% on the 20-ampere range and reduces to less than $\pm$0.5% on the 0.05-ampere range.

CALIBRATION OF AC WATTMETERS BY DC METHOD

Most electrodynamic AC wattmeters can be checked with DC voltages and currents. When the OUTPUT switch is at DC and the RANGE SELECTOR is at WATTS DC, both the voltage and current sides of the equipment are active. The WATTS SELECTOR lever switch places the DC standard instrument in either the multiplier circuit of the voltage side or the shunt circuit of the current side. As the instrument is transferred from a circuit, an equivalent resistance is connected in its place in order not to change the output current or voltage while the other is being adjusted.

CIRCUIT FOR CALIBRATION OF AC VOLTMETERS, AC MILLIVOLTMETERS, AND AC MILLIAMMETERS

The AC voltage circuits are set up by switches as shown in Figure 12. The switches are shown set up for 300 volts AC. The potential transformer is an accurately wound and tapped unit with the turns ratios set, so that under unloaded conditions, the output voltages are about $\pm$0.2% high and with full burden applied are about $\pm$0.2% low. The AC millivolt ranges are for the calibration of vacuum tube voltmeters.

For AC milliammeter calibration, decade resistor (R-102) is connected in series with the AC milliammeter under test. Enough decade resistance is then added (by adjusting the white knobs) to the AC resistance of the instrument under test so as to make the circuit have a total impedance of 10,000 ohms at the frequency of calibration. When using 10,000 ohms as reference total circuit impedance, the various milliampere ranges will require the voltage sources given in Table 5.

To set the decade resistor properly so as to give an impedance of 10,000 ohms when in series with the AC milliammeter under test, instrument reactance (X_m) and AC resistance (R_{mac}) values at the desired frequency must be known. An inductance bridge will readily give both X_m and R_{mac} values. The instrument will be inductive throughout the frequency range specified by its manufacturer, and its AC resistance will be approximately equal to the DC resistance of its winding, provided the instrument is used within the frequency range specified by the manufacturer. Both frequency and DC resistance are usually stamped on the face of the instrument. However, check DC resistance to make sure indicated value is correct.

If X_m measures less than 400 ohms, the decade resistor setting equals the difference between the AC or DC resistance and 10,000 ohms. If X_m measures 400 ohms or greater, refer to the table of X_m and R_t values at the end of this manual. Find instrument X_m value and note corresponding R_t value. Then subtract the instrument AC or DC resistance value from R_t. The difference equals decade resistor setting.

In the event an inductance bridge is not available, another convenient method for arriving at X_m is by means of the instrument impedance Z_m. A variable resistor is connected in series with the instrument and voltage, the voltage having a frequency equal to the calibration frequency. Vary resistance until the voltage drop across it is exactly equal to the voltage drop across the instrument. The series resistance needed for equal voltages equals instrument impedance. Use a vacuum tube voltmeter for negligible loading.

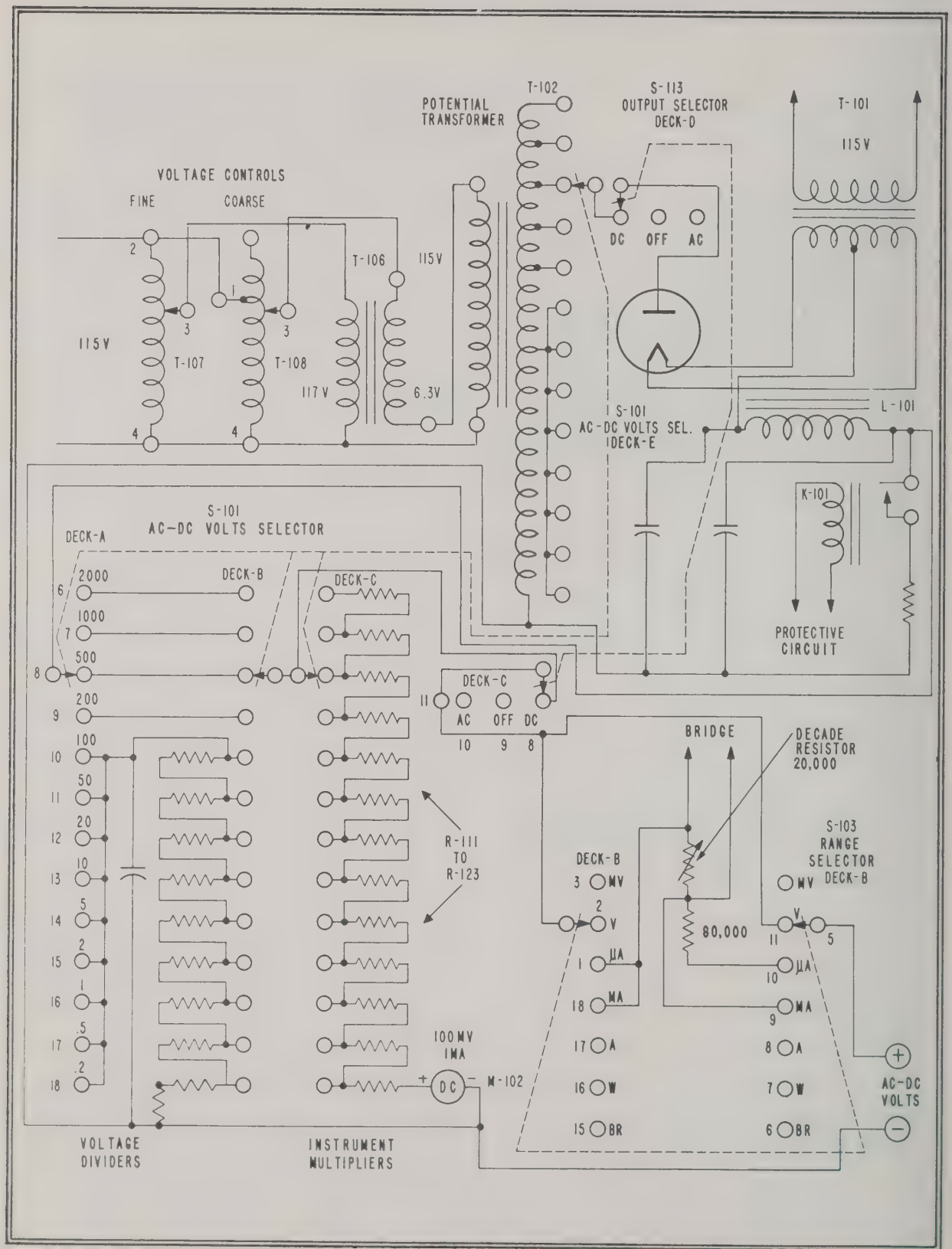


Figure 10. Functional Diagram for DC Voltmeter, DC Milliammeter, and DC Microammeter Calibration.

HOW TO USE CHART FOUND AT THE END OF THIS MANUAL IN CONJUNCTION WITH THE INSTRUMENT IMPEDANCE TO DETERMINE DECADE RESISTOR SETTING:

Given an AC milliammeter whose impedance (Z_m) at 400 cps equals 689 ohms and AC resistance (R_{mac}) is 279.6 ohms, find decade resistor setting.

On the series impedance chart (attached to back cover) first locate on the abscissa (horizontal scale) the AC resistance (R_{mac}) of 279.6 ohms. At that point strike a vertical line until it intersects an impedance radius equal to 689 ohms. Then at that point of intersection strike a horizontal line to the left until the X_m ordinate value (vertical scale) is reached. The X_m value in this case equals 629.59. Next turn to the table of X_m and R_t values and find X_m equals 629.59 or a value closest to it. Then read corresponding R_t value. Now subtract the R_{mac} value from the R_t value.

Closest value to X_m of 629.59 is 600 ohms and corresponding R_t value is 9982. Subtract from 9982 the R_{mac} value of 279.6 ohms. The difference is 9702.4 ohms, which is the decade resistor setting needed at the calibration frequency in order to make a total circuit impedance of 10,000 ohms. Closest setting on the decade resistor is 9700; so it is set at 9700.

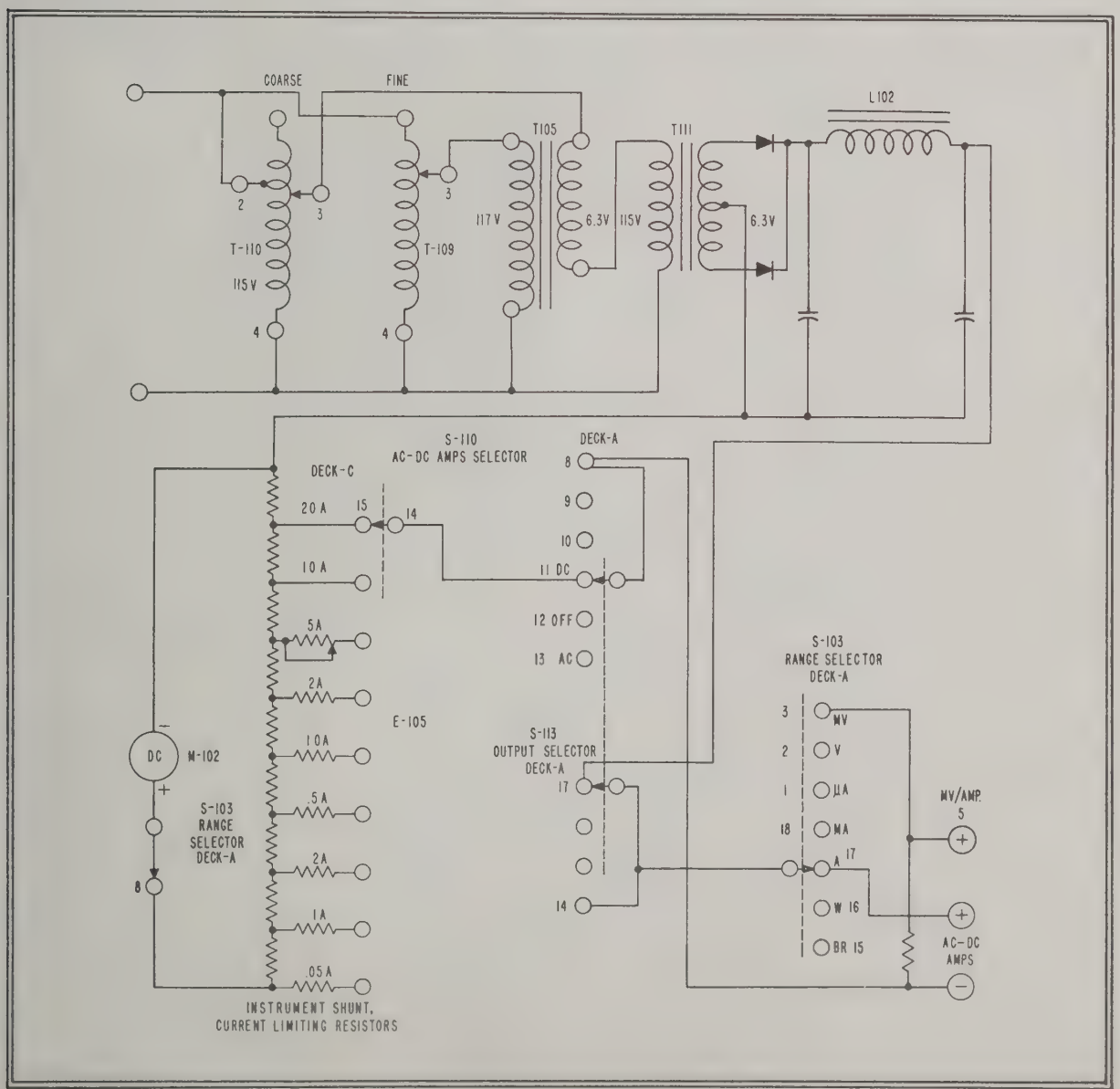


Figure 11. Functional Diagram for DC Ammeter and DC Millivoltmeter Calibration.

Note that the series impedance chart is scaled off from 0 to 10 on both vertical and horizontal axes. Therefore, when working with instrument parameter values greater than 10 but less than 100, let the number 1 point be equal to 10. Then follow both scales with equal increments through to 100. Likewise, with parameter values greater than 100 but less than 1000, let the number 1 point be equal to 100 and work up equal increments on both scales to 1000. For parameter values greater than 1000 but less than 10,000, number 1 is set at 1000 and follow up on both scales with equal increments to 10,000.

CAUTION

Both vertical and horizontal scales must be identical, so that the impedance radii fall on equal horizontal and vertical magnitudes.

This method for computing decade resistor setting is accurate to within 0.2%.

CIRCUIT FOR CALIBRATION OF AC AMMETERS

Figure 13 shows the arrangement of the electrical parts for AC current calibrations. The first six windings of the potential transformer are used to supply the AC current to the current transformer and external load. The AC standard instrument is used as a basic 75 MA instrument by connecting the current transformer directly across the field coils. The SELECTOR switch determines the proper taps on the potential and current transformers for the range desired.

Figure 14 shows a simplified schematic of the control circuits. The function of the control circuit is to remove power from the equipment and discharge the high voltage

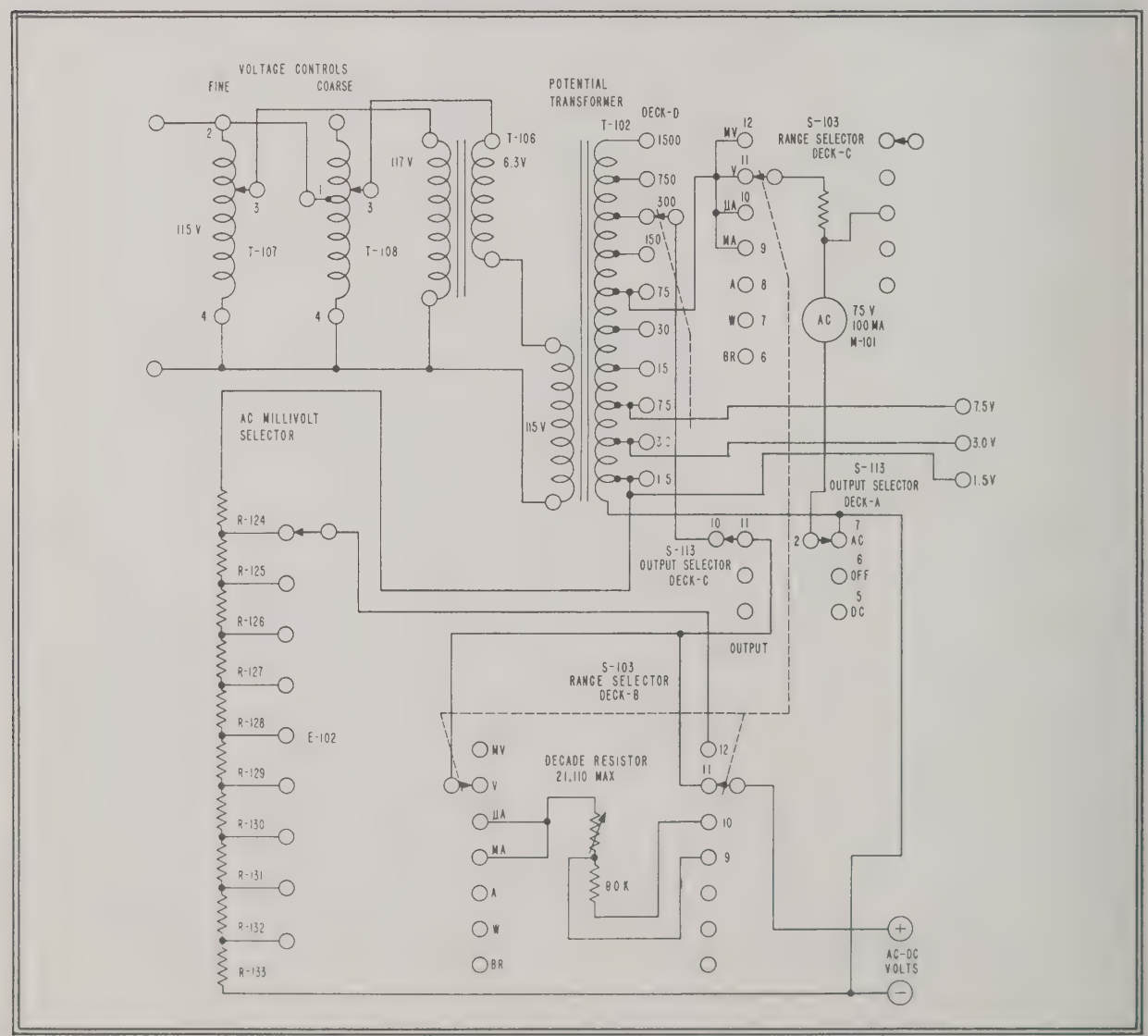


Figure 12. Functional Diagram for AC Voltmeter, AC Millivoltmeter, and AC Milliammeter Calibration.

capacitors whenever the equipment is turned off or a selector switch is moved, unless the VOLTAGE and CURRENT CONTROLS are at zero (the maximum counterclockwise position). Microswitches on each switch shaft break the holding circuit of the relay whenever the switch is moved. The circuit also discharges the capacitors in the high voltage power supply at the instant the VOLTAGE and CURRENT CONTROLS are returned to zero.

When the POWER switch is turned to ON, the green EQUIPMENT lamp lights, and 30 seconds later the thermal time delay relay closes and applies power to the holding relay, which closes and applies power to the equipment when the VOLTAGE and CURRENT CONTROLS are at zero and their microswitches are closed.

As the controls are moved up-scale, the microswitches open, but power is maintained on the equipment by the holding relay. Five microswitches attached to the shafts of the selector switches are in the coil circuit of the holding relay. A small movement of the shaft of any of these SELECTOR switches will break the current in the holding relay coil and let it drop out to remove the power from the equipment. The COARSE Variac controls must be returned to zero to energize the holding relay again. The high voltage relay is normally closed and so requires current to hold it open. The current is supplied through the normally closed contact of the microswitch on the COARSE voltage Variac. At zero position of the Variac this contact opens, stopping current flow through the high voltage relay which switches a 10,000-ohm bleeder resistor across the high voltage capacitors and discharges them.

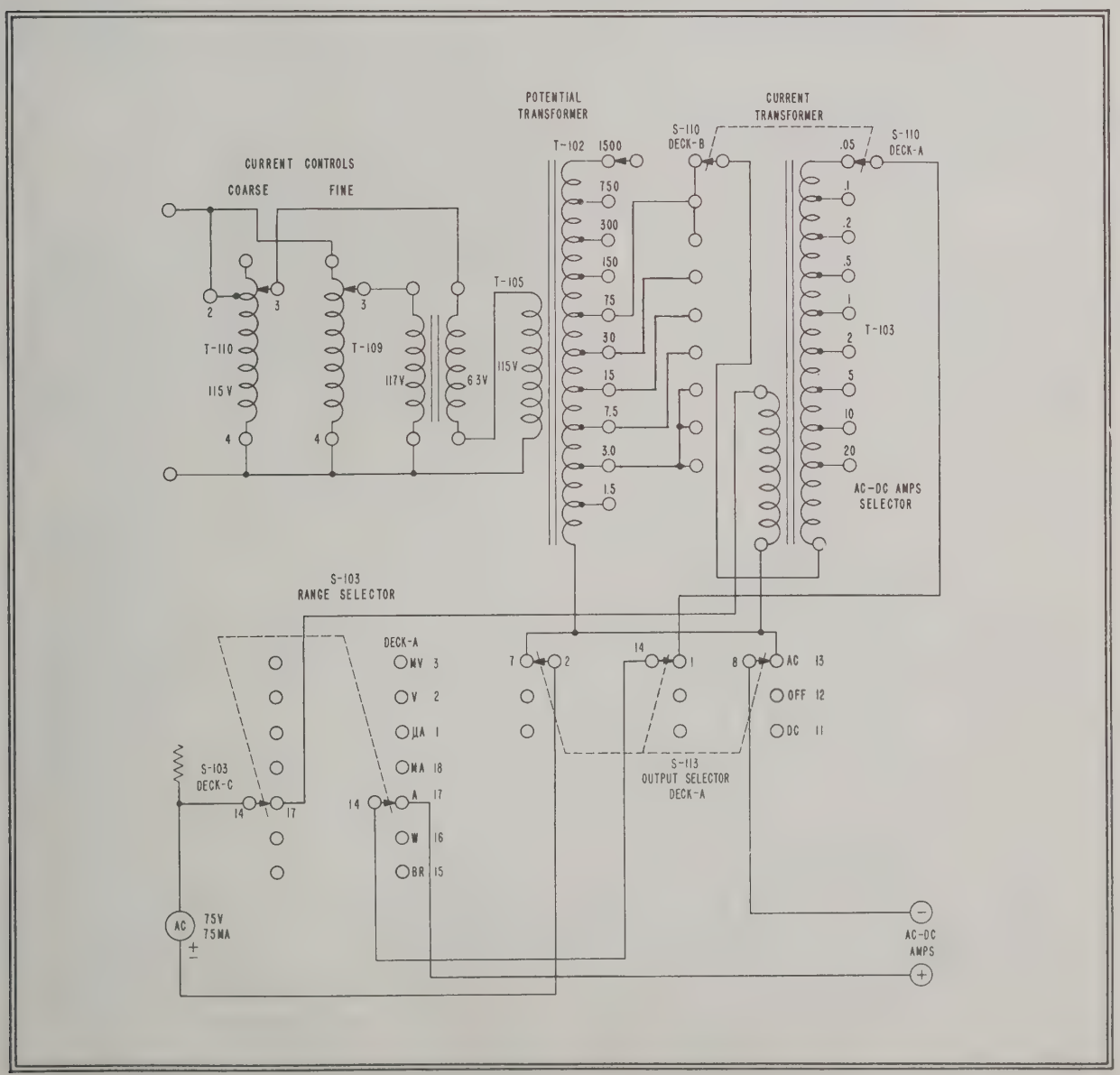


Figure 13. Functional Diagram for AC Ammeters.

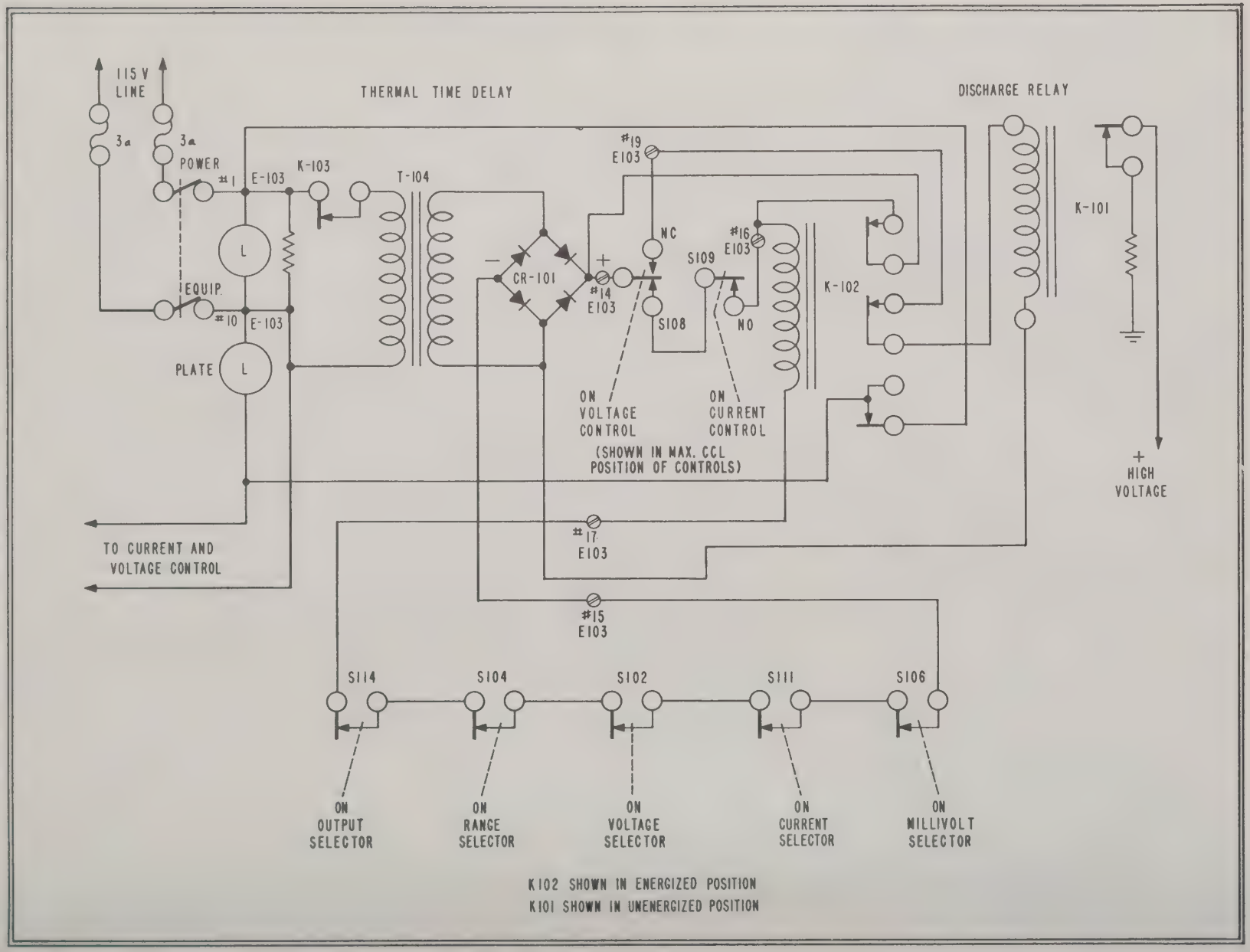


Figure 14. Simplified Schematic Diagram of Control Circuits.

SOURCES OF ERROR IN INSTRUMENTS

Reading Errors

In general, the construction of the pointer and scale is such that readings can be estimated to one-tenth of a scale division. This is possible over most of the scale on moving coil type DC instruments and wattmeters. AC ammeters and voltmeters have crowded scales and usually only half to full-scale can be read accurately.

Most precision instruments have mirrors behind the pointers to allow the reader to move his eyes until the reflection is covered by the pointer, thus eliminating parallax.

If minor fluctuations in readings are observed, the readings should be averaged mentally. Large fluctuations prohibit accurate calibration. This condition can be helped by using a power supply or regulator that will keep amplitude variations to 0.5% for 5% kick on unstable line sources.

Electrical Errors

SHUNTS. - Care must be taken that shunts are not damaged mechanically. All connections to shunts for test must be firmly bolted with clean contacts. Do not over-tighten the bolts and distort the shunt.

EXTERNAL SHUNT AMMETERS. - External shunt ammeters must be calibrated with the same set of leads connecting the shunt and the millivoltmeter as used with the instrument. When connecting the millivoltmeter to the shunt, care must be taken that all contacts are clean and tight. Examine the leads for breaks.

TEMPERATURE. - Electrical instruments are affected by temperature. The temperature is determined by internal heating and the ambient. The temperature effect is to weaken the springs and cause the instrument to read high by 0.03%/C°. In iron instruments the permeability of the iron decreases about the same amount, compensating for the spring constant change. The magnetic field of most instrument magnets weakens with increase of temperature. The temperature coefficient for copper wire is +0.4%/C° rise. In voltmeters the magnitude of this change is reduced by series resistors of zero temperature coefficient wire. Ammeters without shunts are not temperature sensitive. Ammeters with shunts are usually temperature conpensated; if not, the temperature errors can approach the temperature coefficient of copper.

STRAY FIELDS. - Stray fields from connecting wires may cause inaccuracies in the calibration of moving coil ammeters and voltmeters. If stray DC fields are suspected, move the connecting wires. Stray fields will cause a percentage error throughout the scale. DC panel instruments that are intended for use in steel panels must be calibrated in a steel panel. A steel panel distorts the normal field of the internal magnet and changes the readings.

ELECTROSTATIC ATTRACTION. - Electrostatic forces many times exist between the instrument pointer and the glass cover. These surface charges must be dissipated by breathing upon the glass before starting the calibration procedure.

HARMONIC DISTORTION. - Large errors can occur in the calibration of average and peak reading instruments; these errors depend entirely on wave shape. For a peak reading meter, the maximum error can be the same as the harmonic distortion of the power source. For an average reading meter the error is in the order of 1/10 the harmonic distortion or about 0.1% for usual wave shapes.

Inaccuracies can also occur with harmonic distortion in the calibration of electrodynamometer and iron vane AC meters that do not respond accurately to the harmonics. For example: a 60-cycle meter reads 2% low on the 3rd harmonic at 180 cycles and, if the applied wave had 3rd harmonic distortion of 3%, the inaccuracy would be 3% of 2% or .06%. This example applies to the average 60-cycle AC meter and the usual distortion present on a loaded 60 cycle power line.

The harmonic distortion of the usual 60-cycle power line of 1-1/2 - 2% can be reduced to 0.25 - 0.5% by inserting a power supply (having a low distortion output) between the line and the Model 829/829A.

Mechanical Errors

FRICTION. - Before calibrating an instrument, it should be checked for friction. This is done by energizing the instrument and slowly moving the pointer over the whole scale, stopping at several points. Excessive friction will be evident by a sudden change of reading when the instrument is tapped. Excessive friction may be due to a cracked jewel or other injury due to dropping, buckling of the paper scale, projecting hairs and fibers, dust, or magnetic particles in the air gap.

SPRINGS. - The zero may shift due to the mechanical yielding of the spring. A screw on the face of the instrument is usually provided to correct this.

BALANCE. - The moving system of an instrument should be in good balance. Good balance is checked by bringing the instrument up to half-scale reading, then placing it successively on its near side, right side, and left side with no (or very small) change in reading. Instruments should always be calibrated in the same position as used.

WARNING

This equipment operates at dangerous voltages. Men have been killed by very low voltage circuits. As little as 30 volts may be fatal under the proper combination of circumstances. Haste, heedlessness, attempts to work where there are distracting noises, and attempts to carry on a conversation while servicing lead to personnel and materiel casualties.

Maintenance

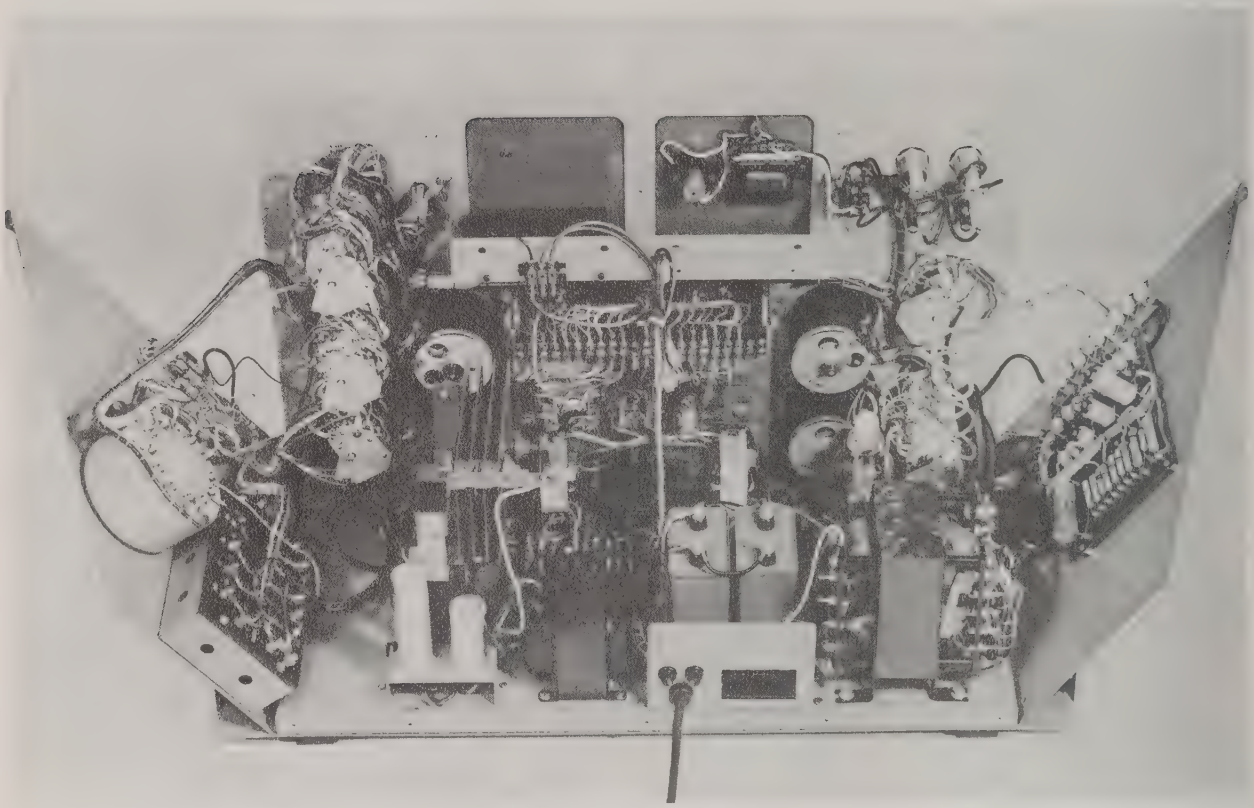


Figure 15. Top View of Model 829A AC-DC Instrument Calibration Standard with Side Panels Loosened for Servicing.

GENERAL

Periodic inspection should be made to see that all screws and bolts are tight. If trouble should develop in the precision instrument transformers T-102 and T-103 or the instruments shunts E-104 and E-112, they should be replaced from the factory and no attempt made to repair them. The switches and controls are equipped with microswitch interlocks operating from the detent mechanism. These interlocks may require periodic adjustment. Figure 15 shows cover removed and side plates loosened.

TROUBLE CHART

Table 6. contains a list of troubles and operational difficulties which may be encountered. In the second and third columns are listed their probable causes and recommended remedies. Refer to schematic diagram.

CALIBRATION CHECK

In the design of the Models 829/829A AC-DC Instrument Calibration Standards specific emphasis was placed on long-time stability and the maintenance of calibration accuracies. If not subjected to abnormal usage, this equipment will maintain its accuracy for many years. It is recommended, however, that a periodic spot check be performed every 6 months at which time a few DC current and voltage ranges as well as AC voltage and current ranges should be calibrated against standards such as the Model 1605, Type K potentiometer, or a 0.25% AC-DC meter of known accuracy. This is accomplished by placing the standards across the output terminals and setting the Model 829 or 829A to full-scale value on the ranges calibrated.

The standard meters in both models are checked in the factory during final calibration. A record is made of the full-scale sensitivity of each meter and is filed for each serial numbered equipment. This sensitivity is marked on each meter. A replacement or repair of a meter can be accomplished by removing it from the equipment and returning it to the factory. This eliminates returning the entire Instrument Calibration Standard to the factory for recalibration.

Table 6. Trouble Chart

DC SECTION

SYMPTOM	CAUSE	REMEDY
DC VOLTS		
a. No voltage output. No standard meter reading. I-102 does not light.	Jumpers on E-111.	Check for proper connection of jumpers.
	Blown fuse F-101, F-102.	Replace fuse.
	Faulty equipment switch S-112.	Check and replace if necessary.
	Faulty jack J-101.	Check and replace if necessary.
b. No voltage output. Pilot lamp I-101 does not light.	Faulty thermal delay relay K-103.	Check resistance between contacts 2 and 3 and measure heater resistance; approximately 6000 ohms.
	Open interlock circuit.	Check to see that both COARSE CONTROLS are fully counter-clockwise.
		Check to see that all switch detents are fully seated.
		Check continuity of interlock switch circuits; should show short circuit from terminal #17 to terminal #20 of E-103.
	Faulty transformer T-104.	Check T-104.
		Primary resistance 22 ohms. Secondary resistance less than 1 ohm. Secondary voltage 15 volts.
	Faulty selenium rectifier CR-101.	Check AC volts, input 15 volts.
		Check DC volts, output 12 volts.
	Faulty relay K-102.	Check for 12 volts dc across coil when thermal delay relay closes. Check relay contacts.
c. No voltage output. No standard meter reading.	Fuse F-104 open.	Check and replace if necessary.
	Relay K-101 fails to open when COARSE VOLTAGE CONTROL is rotated clockwise.	Check for 12 volts dc across relay coil when COARSE VOLTAGE CONTROL is turned clockwise. If 12 volts dc is present across coil, check continuity of relay coil, approximately 26 ohms. Check relay for sticking contacts.
	Open interlock circuit.	Check continuity of terminal board E-103. (1) Disconnect from line. Should show short circuit from #15 of terminal board E-103 to #17 of E-103; (2) with COARSE VOLTAGE and CURRENT CONTROLS at CCL position, a short exists between terminals #14 and #16; open between #14 and #19; (3) short circuit exists between #15 and #17 when all interlocks are closed.

Table 6. Trouble Chart (Continued)

SYMPTOM	CAUSE	REMEDY
	Faulty 836 rectifier tube.	Check and replace if necessary.
	Faulty filament transformer T-101.	Check AC volts to primary - 15 volts from #7 to #8 on E-111. Check resistance of primary of T-101. Disconnect black and black and red leads from rear of E-111. Terminals #7 and #8 should show a resistance of 42 ohms across these two leads.
	Shorted filter capacitor C-101 and C-102.	Check and replace if necessary.
	Open contact in AC-DC VOLTS SELECTOR S-101.	Check continuity.
	Short in AC-DC VOLTS SELECTOR circuit S-101.	Disconnect one side of dc standard meter. Hold relay K-101 open. From #19 of A deck, S-101 to minus volts terminal resistances should read as follows: Position of S-101 - .2 to 100 volts - 1765 ohms; 200 to 2000 volts - ∞ .
d. Voltage is present at output terminals, but standard meter does not read.	Faulty meter.	Disconnect dc meter from circuit and insert 1 MA dc meter in its place. If 1 MA meter reads as voltage controls are increased, this indicates that standard meter is defective.
	Open multiplier.	Disconnect one side of dc standard meter M-102 and check resistance of multiplier.
	Switching circuits.	Disconnect one side of dc standard meter M-102. Check S-101 for open contacts as short circuit to ground.
e. Standard meter reads, but no voltage is present at voltage output terminals.	Switching circuits.	Open contact on wiring in S-101, S-103, or S-113. A check should show continuity for #19 B deck S-102 to positive voltage output terminal.
DC MILLIAMPERES		
a. No current at MA output terminals. No standard meter reading.	Check as per DC Volts.	
b. Current at current output terminals, but standard meter does not read.	Check as per DC Volts.	
c. Standard meter reads, but there is no current at output terminals.	Switching circuits.	Check contacts in S-113 and S-103.
	Open decade resistor.	Check resistance of decades.

Table 6. Trouble Chart (Continued)

SYMPTOM	CAUSE	REMEDY
DC MICROAMPERES		
a. Same as milliampere symptoms.	Same as milliampere, with the addition of a possible open 90 K resistor R-147.	
DC CURRENT .05-20 AMPERES		
a. No current present at current terminals; standard meter does not read.	Check interlocks.	Check and replace if necessary.
	Blown fuse F-103.	Check for 8 volts dc on terminal board E-111 from #1 to #2.
	Faulty current supply circuit.	Check for 12 volts ac from #3 to #4 of E-111. Check continuity and for short circuit to chassis on choke L-102.
		Check C-104 and C-108 for short circuit.
		Check for 115 volts ac into T-111; #6 to #8 of E-111.
		Check resistance of primary of T-111. Disconnect leads from T-111 going to #6 and #8 of E-111. Resistance across these leads is approximately 2 ohms.
	Switch circuit.	Check S-113 and S-103.
	Faulty shunt E-104.	Check and replace. Do not attempt to repair. Return shunt to factory for repairs.
	Faulty current limiting resistors .05 to 5 amp position.	Check resistors R-135 through R-141.
DC WATTS		
a. No standard meter reading. No output.	Voltage or current sections inoperative.	Check as in DC Voltage and DC Current sections.
		Check through S-103 in watts position.
b. Output is present at terminals, but standard meter does not read in either position of WATTS SELECTOR S-107.	Faulty WATTS SELECTOR S-107.	Check contacts of S-107.
	Faulty voltage measuring circuit.	Check as per voltage troubles.
	Faulty current measuring circuit.	Check as per current troubles.

Table 6. Trouble Chart (Continued)

SYMPTOM	CAUSE	REMEDY
DC MILLIVOLTS		
a. No output. No meter reading.	Same as DC Current causes.	See DC Current failure remedies.
	Faulty millivolt shunt E-112 or switching circuit of S-103.	Check connections to millivolt shunt E-112. Check continuity of S-103.
BRIDGE		
a. No reading.	AC power supply circuit.	Check as per DC Current troubles.
	Check for presence of 8 volt dc across #2 and #6 of E-103.	If voltage is present it shows supply is operating. If no voltage, check continuity through S-103 and S-113 back to CR-102 and T-111.
	Meter.	Check null indicator as a microammeter using 829 standard equipment.
b. Meter shows excessive deflection with any setting of decade and/or ratio dial.	Open decade or ratio coil.	Check decade and coils for continuity.
	Defective or dirty switch contact.	Repair, clean or replace. Check S-117 and S-115.
		Check J-102. Clean contacts if necessary.
c. No external galvanometer reading. Internal galvanometer reads properly.	Faulty jack J-102.	Check J-102. Clean contacts, replace jack if necessary.

AC SECTION

AC VOLTS		
a. See a and b under DC Volts. Check accordingly.		
b. No voltage at output. No standard meter reading.	Fuse F-104.	Check and replace if necessary.
	Potential transformer T-102.	Check continuity across primary (115-115). Check resistance of primary of potential transformer, approximately 1 ohm.
	Switching circuit.	Check continuity of S-103 and S-113.
c. Standard meter reads, but no voltage across output terminals.	Switching circuit.	Check S-103 and S-113. Note 1.5 and 3.0 volts go directly to terminal and also through S-103 and S-113.

Table 6. Trouble Chart (Continued)

SYMPTOM	CAUSE	REMEDY
d. Voltage is at output terminals, but standard meter does not read.	Meter circuit.	Check for 75 volts at 75 volts tap of T-102 with power applied to primary. CAUTION: Extremely high voltages are present on other terminals of this transformer. Exercise extreme care. Check standard meter, M-102. Check meter switching circuits S-103 and S-113.
AC CURRENT		
a. No current at output terminals. No standard meter reading.	Defective potential transformer T-102.	Check input and output voltages of T-102. Check resistance of primary of T-102, 1 ohm. Check continuity of secondaries of T-102, 1.5 to 75 volt range.
	Faulty switching circuit.	Check S-103, S-110, and S-113.
	Faulty current transformers.	Check primary of T-103 for open circuit. ± Terminal to: 20.0 A, 10.0, 5.0, 2.0, 1.0, 0.5 — Less than 1 ohm 0.2 — 6 Ohm 0.1 — 18 0.05 — 60
b. Very little or no current at output terminals, but standard meter reads.	Faulty current transformers.	Short circuit in primary of current transformer. Check resistances as per AC Current, faulty current transformers.
	Short circuit across current output terminals.	Check, remove short circuit.
c. Current at output terminals, but standard meter does not read.	Defective meter.	Check and replace if necessary.
	Defective current transformer.	Check meter winding (secondary) of T-103, resistance is 22 ohms.
AC MILLIVOLTS		
a. No voltage at output. No standard meter reading.	Same causes as AC Volts, a and b.	Check under same symptoms as per AC Volts, a and b.

Table 6. Trouble Chart (Continued)

SYMPTOM	CAUSE	REMEDY
b. Voltage present at output terminals, but no standard meter reading.	Potential transformers.	Check continuity and voltage output of 75-volt winding of T-102.
	Metering circuits.	Check switching circuits for continuity or short circuits, S-103.
	Defective meter.	Check meter, replace if necessary.
c. Standard meter reads, but no voltage at AC millivolt terminals.	Open voltage divider.	Check R-124 through R-133.
	Defective AC MILLIVOLTS switch S-106.	Check contacts and wiring.
	Faulty switching circuits.	S-103, S-113, and S-106.
AC MILLIAMPERES		
a. Meter reads, but no output at terminals.	Open decade resistance.	Check decade resistances.
b. All other symptoms check as per AC Voltage troubles.		

Table of Replaceable Parts

INTRODUCTION

The Table of Replaceable Parts included in this section lists all electrical parts for maintenance and procurement purposes in case of failure. These parts can be obtained from the Radio Frequency Laboratories, Inc., Boonton, New Jersey.

REFERENCE SYMBOLS

The reference symbols given in the Table of Replaceable Parts correspond to those appearing in the figures and test. Each reference symbol consists of a hyphenated combination of one or two capital letters and three or more significant figures. (For example C-101.) The alphabetical portion of the reference symbol indicates the type of apparatus or component as classified.

Each component part covered by the same symbol designation is assigned a number running consecutively for 99 numbers, from 101 - 199.

SYMBOL	DESCRIPTION
A	Structural Parts, Panels, Etc.
BT	Batteries
C	Capacitors
CR	Rectifiers
E	Miscellaneous Electrical Parts
F	Fuses
HR	Heating Elements
I	Pilot Lamps
J	Jacks and Receptacles
K	Relays
L	Reactors
M	Meters
O	Mechanical Parts
P	Plugs
R	Resistors
S	Switches
T	Transformers
V	Vacuum Tubes
X	Sockets

Table 7. Table of Replaceable Parts

REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
C-101	CAPACITOR, Fixed, oil filled: 4 mf, 2000 v DC.	High voltage supply filter output capacitor.	HA-6430
C-102	CAPACITOR, Fixed, oil filled: Same as C-101.	High voltage supply filter input capacitor.	
C-103	CAPACITOR, Fixed, electrolytic: 40 mf, 250 v DC.	Low voltage filter.	HA-6474
C-104	CAPACITOR, Fixed, electrolytic: 4000 mf, 10 v DC.	Current supply filter input capacitor.	HA-6472
C-105	CAPACITOR, Fixed, electrolytic: 2000 mf, 10 v DC.	Current supply filter output capacitor.	HA-6473
CR-101	RECTIFIER, Metallic: selenium; 26 v AC, 19 v DC, 0.45 amp.	Relay supply rectifier.	HA-4444
CR-102	RECTIFIER, Metallic: approximately 4 v AC, 2 v DC, 20 amp.	Current supply rectifier.	HB-3089
E-101	TERMINAL BOARD, Laminated phenolic: non-barrier type; incl 48 solder lug terms.	DC voltage divider and meter multiplier resistor mounting board.	HC-6601
E-102	TERMINAL BOARD, Laminated phenolic: non-barrier type; incl 20 solder lug terms.	AC millivolts voltage divider.	HB-6571
E-103	TERMINAL STRIP: 20 terminals; bakelite.	Relay panel terminal strip.	HA-6489
E-104	SHUNT ASSEMBLY: contains 9 shunts mtd on bakelite panel.	Precision DC shunt, 0.05 to 20 amps, 100 mv.	HC-6471
E-105	TERMINAL BOARD, Laminated phenolic: non-barrier type; incl 8 solder lug terms.	Current limiting resistor mounting board.	HB-6609
E-106	FUSEHOLDER: 15 amps, 250 v, 3 AG; screwdriver slot knob.	Holder for F-101	HA-1291
E-107	FUSEHOLDER: Same as E-106.	Holder for F-102.	
E-108	FUSEHOLDER: 15 amps, 250 v, 3 AG; finger operated knob.	Holder for F-103.	HA-1816
E-109	FUSEHOLDER: Same as E-108.	Holder for F-104.	
E-110	TERMINAL STRIP: 3 terminals; bakelite.	Meter resistor termination.	HA-12002
E-111	TERMINAL STRIP. 12 terminals; bakelite.	DC current supply terminal strip.	HA-12001
E-112	SHUNT: 100 mv at 20 amps; accuracy 0.1%.	DC millivolts shunt.	HA-6447
E-113	TERMINAL BOARD, Laminated phenolic.	AC-DC VOLTS, AC MV and DC μA, AC-DC MA output terminal board.	HA-6592

Table 7. Table of Replaceable Parts (Continued)

REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
E-114	TERMINAL BOARD, Laminated phenolic.	AC-DC AMPS and DC MV output terminal board.	HA-6594
E-115	TERMINAL BOARD, Laminated phenolic.	Relay panel.	HB-6596
E-116	KNOB, w/o pointer: molded phenolic; fluted knobs; brass insert for 3/8" shaft.	Knob for T-107.	HA-6436
E-117	KNOB, w/o pointer: Same as E-116.	Knob for T-108.	
E-118	KNOB, w/o pointer: Same as E-116.	Knob for T-109.	
E-119	KNOB, w/o pointer: Same as E-116.	Knob for T-110.	
E-120	KNOB, Pointer: set screw type, black.	Bridge ratio setting knob.	HA-6479
E-121	KNOB, Pointer: set screw type, white.	Knob for R-143.	HA-6529
E-122	KNOB, Pointer: Same as E-121.	Knob for R-144.	
E-123	KNOB, Pointer: Same as E-121.	Knob for R-145.	
E-124	KNOB, Pointer: Same as E-121.	Knob for R-146.	
E-125	KNOB, Pointer: set screw type, black bakelite.	Bridge ratio control knob.	HA-6530
E-126	KNOB, w/pointer: molded phenolic; fluted knob; brass insert bored for 3/8" shaft.	Knob for S-101.	HA-6631
E-127	POST, Binding: non-removable knob of molded phenolic; w/dowel.	Bridge binding posts for unknown resistance and external battery connections.	HA-3688
E-128	POST, Binding: Same as E-127.	Bridge binding posts for unknown resistance and external battery connections.	
E-129	POST, Binding: Same as E-127.	Bridge binding posts for unknown resistance and external battery connections.	
E-130	POST, Binding: Same as E-127.	Bridge binding posts for unknown resistance and external battery connections.	
E-131	POST, Binding: screw type; brass nickel plate.	AC-DC current and DC MV output terminals.	HA-6633
E-132	POST, Binding: Same as E-131.	AC-DC current and DC MV output terminals.	
E-133	POST, Binding: Same as E-131.	AC-DC current and DC MV output terminals.	

Table 7. Table of Replaceable Parts (Continued)

REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
E-134	POST, Binding: molded phenolic; locking type; black.	AC-DC VOLTS, AC-DC MA, DC, μA, and AC millivolt binding post.	HA-6481-1
E-135	POST, Binding: Same as E-134.	AC-DC VOLTS, AC-DC MA, DC, μA, and AC millivolt binding post.	
E-136	POST, Binding: Same as E-134.	AC-DC VOLTS, AC-DC MA, DC, μA, and AC millivolt binding post.	
E-137	POST, Binding: Same as E-134.	AC-DC VOLTS, AC-DC MA, DC, μA, and AC millivolt binding post.	
E-138	POST, Binding: Same as E-134.	AC-DC VOLTS, AC-DC MA, DC, μA, and AC millivolt binding post.	
F-101	FUSE, Cartridge: 3 amp, 125 v.	Equipment fuse.	HA-6607
F-102	FUSE, Cartridge: Same as F-101.	Equipment fuse.	
F-103	FUSE, Cartridge: 2 amp, 250 v; quick-acting, glass body.	Current supply overload protective fuse.	HA-1289
F-104	FUSE, Cartridge: 3 AG, 1 amp, 250 v; quick-acting, glass body.	Voltage supply protective	HA-4227
I-101	LAMP, Incandescent: 120 v, 6 w.		HA-2873
I-102	LAMP, Incandescent: Same as I-101.		
I-103	LAMP, Lumiline: 40 w, disc base.	Panel light (Model 829A)	HA-2746
J-101	CONNECTOR, Female: 10 contact.	External meter jack.	HA-10964
J-102	JACK, Telephone: single closed circuit, 3 cond.	External galvanometer jack.	HA-6605
K-101	RELAY, SPDT: 12 v, 8 amp, 115 v at 60 cyc,	High voltage discharge protective relay.	HA-6163
K-102	RELAY, 3PST: 12 v DC, 3 amp; 115 v at 60 cyc, non-inductive load.	Switching circuit protective	HB-6653
K-103	RELAY, Thermal delay, SPST: 115 v AC, 3 amp.	Plate voltage delay relay.	HA-3082
L-101	CHOKE, Filter: 10 hy at 100 ma; 5000 v insul.	Voltage supply filter choke.	HB-6441
L-102	CHOKE, Filter: induc .015 hy at 1.2 amps; 1500 v insul, max. DC resistance .096 ohm.	Current supply filter choke.	HB-6444
M-101	METER: AC voltmeter; range 75 volts adjusted to 75 ma; 50 to 440 cyc; knife-edge pointer; acc 3/4%.	AC standard meter. (Model 829)	HC-6438

Table 7. Table of Replaceable Parts (Continued)

REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
M-102	METER: DC milliammeter; range 1 ma; resistance 100 ohms; knife-edge pointer; acc 3/4%.	DC standard meter. (Model 829)	HC-6439
M-103	METER: null indicator; 100-0-100 us; resistance 1000 ohms; bakelite case.	Bridge null indicator.	HA-6606
M-104	METER: AC voltmeter.	AC standard meter (Model 829A)	HC-9990 HB-12,948
M-105	METER: DC milliammeter.	DC standard meter (Model 829A)	HC-9991 HB-12,949
P-101	CONNECTOR, Male: 3 prong, 3/grip cds.	Power input plug.	HA-7763
P-102	CONNECTOR, Male: 10 contact.	External meter jack shorting plug (Model 829)	HA-10965
R-101	RESISTOR, Fixed WW: 800 ohm, ±10%, 10 w.	DC voltage divider.	H-1100-175
R-102	RESISTOR, Fixed WW: 500 ohm, ±10%, 5 w.	DC voltage divider.	H-1100-176
R-103	RESISTOR, Fixed WW: 200 ohm, ±5%, 2 w.	DC voltage divider.	H-1100-168
R-104	RESISTOR, Fixed WW: 130 ohm, ±5%, 1 w.	DC voltage divider.	H-1100-169
R-105	RESISTOR, Fixed WW: 82 ohm, ±10%, 1 w.	DC voltage divider.	H-1100-170
R-106	RESISTOR, Fixed WW: 3.3 ohm, ±10%, 1 w.	DC voltage divider.	H-1100-174
R-107	RESISTOR, Fixed WW: Same as R-106.	DC voltage divider.	
R-108	RESISTOR, Fixed WW: 10 ohm, ±10%, 1 w.	DC voltage divider.	H-1100-173
R-109	RESISTOR, Fixed WW: 13 ohm, ±10%, 1 w.	DC voltage divider.	H-1100-172
R-110	RESISTOR, Fixed WW: 24 ohm, ±10%, 1 w.	DC voltage divider.	H-1100-171
R-111	RESISTOR, Fixed WW: 1 meg, ±0.1%, 2 w.	DC voltmeter multiplier.	H-1060-12
R-112	RESISTOR, Fixed WW: 500 K, ±0.1%, 1.5 w.	DC voltmeter multiplier.	H-1060-13
R-113	RESISTOR, Fixed WW: 300 K, ±0.1%, 1 w.	DC voltmeter multiplier.	H-1060-14
R-114	RESISTOR, Fixed WW: 100 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-15
R-115	RESISTOR, Fixed WW: 50 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-16
R-116	RESISTOR, Fixed WW: 30 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-17
R-117	RESISTOR, Fixed WW: 10 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-18
R-118	RESISTOR, Fixed WW: 5 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-19
R-119	RESISTOR, Fixed WW: 3 K, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-20
R-120	RESISTOR, Fixed WW: 1 K, ±0.1%, 0.33 w.	DC voltmeter multiplier.	H-1060-31
R-121	RESISTOR, Fixed WW: 500 ohm, ±0.1%, 0.33 w.	Meter multiplier.	H-1060-21

Table 7. Table of Replaceable Parts (Continued)

REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
R-122	RESISTOR, Fixed WW: 300 ohm, ±0.1%, 0.33 w.	DC voltmeter multiplier.	H-1060-22
R-123	RESISTOR, Fixed WW: 100 ohm, ±0.1%, 0.33 w.	DC voltmeter multiplier.	H-1060-23
R-124	RESISTOR, Fixed WW: Same as R-121.	AC mv voltage divider.	
R-125	RESISTOR, Fixed WW: Same as R-122.	AC mv voltage divider.	
R-126	RESISTOR, Fixed WW: Same as R-123.	AC mv voltage divider.	
R-127	RESISTOR, Fixed WW: 50 ohm, ±0.1%, 0.33 w.	AC mv divider.	H-1060-24
R-128	RESISTOR, Fixed WW: 30 ohm, ±0.1%, 0.33 w.	AC mv divider.	H-1060-25
R-129	RESISTOR, Fixed WW: 10 ohm, ±0.1%, 0.33 w.	AC mv divider.	H-1060-26
R-130	RESISTOR, Fixed WW: 5 ohm, ±0.1%, 0.33 w.	AC mv voltage divider.	H-1060-27
R-131	RESISTOR, Fixed WW: 3 ohm, ±0.1%, 0.33 w.	AC mv voltage divider.	H-1060-28
R-132	RESISTOR, Fixed WW: 1 ohm, ±0.1%, 0.33 w.	AC mv voltage divider.	H-1060-29
R-133	RESISTOR, Fixed WW: Same as R-132.	AC mv voltage divider.	
R-134	RESISTOR, Fixed WW: 10 K, ±10%, 25 w.	Protective circuit bleeder resistor.	H-1100-188
R-135	RESISTOR, Adj WW: 1 ohm, ±10%, 25 w; w/ mtg brackets and lug terminals.	Current limiting resistor.	H-1100-182
R-136	RESISTOR, Fixed WW: 2 ohm, ±10%, 10 w; w/ mtg brackets and lug terminals.	Current limiting resistor.	H-1100-181
R-137	RESISTOR, Fixed WW: 4 ohm, ±10%, 10 w; w/ mtg brackets and lug terminals.	Current limiting resistor.	H-1100-180
R-138	RESISTOR, Fixed WW: 10 ohm, ±10%, 5 w; w/ mtg brackets and lug terminals.	Current limiting resistor.	H-1100-185
R-139	RESISTOR, Fixed WW: 18 ohm, ±10%, 2 w.	Current limiting resistor.	H-1100-184
R-140	RESISTOR, Fixed WW: 47 ohm, ±10%, 1 w.	Current limiting resistor.	H-1100-183
R-141	RESISTOR, Fixed WW: 100 ohm, ±10%, 1 w.	Current limiting resistor.	H-1100-186
R-142	RESISTOR, Fixed comp: 100 ohm, ±5%, 1 w.	Meter substitution resistor.	H-1009-182
R-143	RESISTOR, Decade: 10 K total resistance, w/35 ma rating, 0.1% tol.	Decade resistor.	HA-6426
R-144	RESISTOR, Decade: total resistance 1 K, 0.1% tolerance.	Decade resistor.	HA-6425
R-145	RESISTOR, Decade: total resistance 100 ohms, 0.1% tolerance.	Decade resistor.	HA-6424

Table 7. Table of Replaceable Parts (Continued)

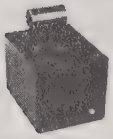
REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
R-146	RESISTOR, Decade: total resistance 10 ohms, 0.25% tolerance.	Decade resistor.	HA-6423
R-147	RESISTOR, Decade: total resistance 80 K, 0.1% tolerance.	Decade resistor.	H-1060-50
R-148	RESISTOR, Fixed WW: 20 ohm, ±10%, 5 w.	Ratio decade resistor.	H-1100-189
R-149	RESISTOR, Fixed WW: 100 ohm, ±0.1%, 0.33 w.	Ratio decade resistor.	H-1060-23
R-150	RESISTOR, Fixed WW: Same as R-120.	Ratio decade resistor.	
R-151	RESISTOR, Fixed WW: Same as R-114.	Ratio decade resistor.	
R-152	RESISTOR, Fixed WW: Same as R-117.	Ratio decade resistor.	
R-153	RESISTOR, Fixed WW: Same as R-120.	Ratio decade resistor.	
R-154	RESISTOR, Fixed WW: Same as R-129.	Ratio decade resistor.	
R-155	RESISTOR, Fixed WW: Same as R-132.	Ratio decade resistor.	
R-156	RESISTOR, Fixed WW: 10 K, ±0.05%, 1 w.	Ratio decade resistor.	H-1060-49
S-101	SWITCH, Rotary: 13 pos, 5 sect, 1 pole/sect.	Voltage range selector.	HB-6418
S-102	SWITCH, Sensitive: SPDT; ultra-small, 10 amp, 250 v ac; w/auxiliary actuator.	Protective circuit microswitch on S-101.	HA-6429
S-103	SWITCH, Rotary: 7 pos, 4 sect, 2 pole/sect.	Range selector.	HB-6420
S-104	SWITCH, Sensitive: Same as S-102.	Protective circuit microswitch on S-103.	
S-105	SWITCH, Rotary: 9 pos, 1 sect, 1 pole.	AC millivolts selector.	HB-6422
S-106	SWITCH, Sensitive: Same as S-102.	Protective circuit microswitch on S-105.	
S-107	SWITCH, Lever: 3 pos, locking type; 3 amp, 120 v ac.	Watts selector.	HB-6434
S-110	SWITCH, Rotary: 9 pos, 3 sect, 1 pole/sect.	AC-DC amps selector.	HB-6419
S-111	SWITCH, Sensitive: Same as S-102.	Protective circuit microswitch on S-110.	
S-112	SWITCH, Toggle: DPST.	Equipment ON-OFF switch.	HA-4337
S-113	SWITCH, Rotary: decks 1 and 2, 3 pos, 4 pole; deck 3, 3 pos, 2 pole.	Output selector.	HB-6476
S-114	SWITCH, Sensitive: Same as S-102.	Protective circuit microswitch on S-113.	
S-115	SWITCH, Push-button: two makes.	Bridge push-to-read switch.	HB-6568

Table 7. Table of Replaceable Parts (Continued)

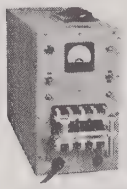
REFERENCE SYMBOL	NAME OF PART AND DESCRIPTION	FUNCTION	RFL PART NO.
S-116	SWITCH, Jack: 2 pos, SPDT.	External battery in-out for bridge.	HA-6457
S-117	SWITCH, Rotary: 11 pos, 2 deck, 1 pole/deck; shorting type.	Bridge ratio setting switch.	HB-6416
S-118	SWITCH, Jack: Same as S-116.	10,000-ohm switch.	
S-119	SWITCH, Toggle: SPST, ST42A.	Panel light (Model 829A)	HA-3709
T-101	TRANSFORMER, Filament: 2.5 v CT at 5 amp; 5000 v insul.	High voltage rectifier filament transformer.	HB-6442
T-102	TRANSFORMER, Potential: 50-400 cps, 75 v at 75 ma.	Potential transformer.	HB-6477
T-103	TRANSFORMER, Current: multi-tapped pri; single secd.	AC current transformer.	HB-6612
T-104	TRANSFORMER, Filament: 15 v at 1.5 amp; 1500 v insul; pri 115 v, 60-400 cps.	Voltage supply transformer for relay circuit.	HB-6443
T-105	TRANSFORMER, Filament: pri 117 v, 60 cyc, 2500 v insul; secd 6.3 v at 3 amp CT.	Booster transformer for Variac controls.	HB-6435
T-106	TRANSFORMER, Filament: Same as T-105.	Booster transformer for Variac controls.	
T-107	TRANSFORMER, Variable: 115 v input, 0-135 v output; 0.345 kva load rating.	Voltage fine control.	HA-6478
T-108	TRANSFORMER, Variable: 115 v input, 0-135 v output, 0.345 kva load rating; w/microswitch.	Voltage coarse control.	HA-6186
T-109	TRANSFORMER, Variable: Same as T-107.	Current fine control.	
T-110	TRANSFORMER, Variable: Same as T-108.	Current coarse control.	
T-111	TRANSFORMER, Filament: 12.6 v CT, 6.3-0-6.3; 1500 v insul; pri 115 v, 60-400 cps; secd rating 10 amp.	DC current supply transformer.	HB-6445
V-101	TUBE, Electron: type 836.	High voltage rectifier.	HA-2859
X-101	SOCKET, Tube: 4 contact.	For Type 836 tube.	HA-2874
X-102	LIGHT, Indicator: w/red lens; candelabra screw base.	Plate supply pilot lamp.	HA-2856
X-103	LIGHT, Indicator: w/green lens; candelabra screw base.	Equipment pilot lamp.	HA-2854
X-104	SOCKET, Electron tube: 8 cont.	Thermal delay relay socket.	HA-2528
X-105	SOCKET, Lumiline base.	Lamp holder (Model 829A)	HA-2744
X-106	SOCKET, Lumiline cap.	Lamp holder (Model 829A)	HA-2745

TEST and SERVICE PRODUCTS

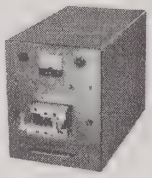
For MAGNET CHARGING, TREATING and CALIBRATION



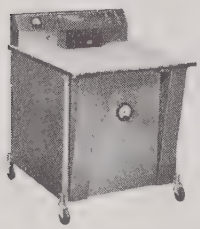
MODEL 1221 is used for small magnets. Its 10,000 ampere-turn output will saturate about 2" of Alnico V. Operates by condenser discharge method thru plug-in fixtures. Uses only 30 watts at 115 v. For continuous duty; charging cycle averages 3 sec.



MODEL 107A is a versatile, condenser discharge magnetizer for most medium size magnets of either simple or complex pole configuration. It provides ranges of 12,000 and 24,000 ampere-turns and is capable of saturating most instrument magnets, including the core type mechanisms, using the standard flat bar, adapters or wire-wound fixtures. Can be used for continuous duty production magnetizing; average charging cycle is under 5 sec. Weight is 75 lbs. Size 12 x 7 x 17. Operates from 115-volt, 60-cycle line.

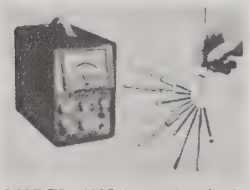


MODEL 1500 is designed for production, research and instrument repair work. It will magnetize the new cobalt platinum and barium ferrite materials as well as all the Alnicos. It will saturate large switchboard meter assemblies and all panel type instruments and uses most existing adapters designed for the Model 107A. Wire-wound fixtures are plugged into the front panel through a safety interlock system providing maximum operator protection. Operates from 115-volt, 60-cycle line. Size 11 x 20 x 15; weight 125 lbs.



MODEL 942 will saturate Alnico magnets weighing up to 34 lbs. and high flux ceramic magnets of any shape or pole configuration. Operates on condenser discharge principle from regular 115-volt, 60-cycle line. Produces charging outputs (depending on number of 100 μf condensers employed) from 100,000 to 200,000 ampere-turns through plug-in transformers, up to 3600 watt-seconds using wire-wound fixtures. Adapters for multi-pole rotors, rod, bar, ring and various other shapes available. Equipped with extensive system of safety interlocks for complete operator protection. Designed for continuous production use with low power consumption. Price of basic unit is less than $2100.

MODEL 889A de-magnetizes saturated magnets to any desired level of flux. Provides a precision method for rapidly treating permanent magnets, including the new core type instrument mechanisms. Used with Model 206A Booster or Model 107A Charger.

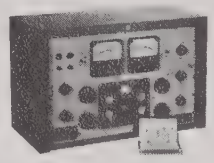


Ten rigid and flexible, flat and axial (Bi and InAs) probes shown offer selection to solve almost any magnet or flux field measurement problem. Axial probes supplied w/ spec. ref. magnets.

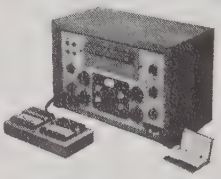
MODEL 1295A transistorized Gaussmeter measures magnetic fields to ±3% accuracy over 9 full-scale ranges: 0-100, 200, 500, 1K, 2K, 5K, 10K, 20K and 20K+ gausses. Operates from 115-V, 50-400 cps or access. bat.

For ELECTRICAL INSTRUMENT CALIBRATION

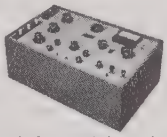
A Model for Every Purpose and Price Range



MODEL 829 checks AC and DC meters of all types and ranges. Compact cabinet contains power supply, special Weston standard meters, Wheatstone Bridge and all circuits for quick, convenient instrument calibration to 0.5% accuracy by non-technical personnel. Automatic protection for both operator and instrument under test is provided by interlocks and high voltage discharge circuits.



MODEL 829A is a higher accuracy version of the Model 829. Separately housed, horizontally mounted Weston or Sensitive Research Standard meters are employed in place of the vertical standards. Full-scale accuracy on all AC and DC ranges is 0.25%. Covers 1.5 mv — 1500 V, 1.5 ma — 20 amp. AC; 0.25 mv — 2000 V, 2 uA — 20 amp. DC.



MODEL 1605 is a self-contained, AC-DC calibration/transfer standard capable of measuring AC (up to 50 kc) and DC voltages and currents up to 1500 volts and 15 amperes with high precision. It includes a volt-box, shunt-box, precision potentiometer, standard cell, galvanometer, thermal converter, plus all necessary compensating and switching circuits. 45 full-scale ranges are provided. Calibrated accuracy: ±0.03% DC, ±0.05% AC.

Nine additional, self-contained console type calibration standards having various accuracies and employing both electrical and electronic circuits are available. They offer three basic methods of calibration: visual comparison against a standard meter, digital presentation, and introduction of a selected, precise voltage or current to the instrument being calibrated. Models are 260C, 261B, 262B, 454, 643, 1294, 1487, 1900 and 1967. Prices from $5000 to $20,000.

For CRYSTAL TESTING

FOUR MODELS developed for Signal Corps under national crystal testing standardization program to measure resonance and anti-resonance resistance of quartz crystals including those covered by MIL-C-3098B. Capacitance, inductance and PI of crystal can be determined.

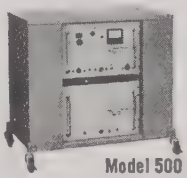
MODEL 459A (Improved TS-330/TSM) covers 800 kc to 15 mc, for 0.002% crystals, 0-9900 ohms. Operates from 115/230 v, 50-1000 cps.

MODEL 531 (TS-683/TSM) Crystal Impedance Meter covers range of 10-140 mc for 10-150 ohm crystals. Twelve fixed calibrating resistors of 10, 22, 30, 40, 51, 60, 68, 82, 91, 100, 120 and 150 ohms, plus a 100-ohm var. resistor for determining crystal resistance. Anti-resonance adapter also provided. Operates from 115/230 v, 50-1000 cps source.

MODEL 541A (TS-710/TSM) for 10-1100 kc range crystals with resistances from 200 ohms to 0.5 megohms. An internal load capacitance is calibrated from 15 to 105 mmf with accuracy better than ±0.5 mmf. Power dissipated in crystal measured by built-in VTVM and ohmmeter. For 115/230 v, 50-1000 cps operation.

MODEL 1207 (AN/TSM-15) covers range of 75-200 mc for 10-125 ohm crystals. Crystal voltage at series resonance is measured within 10%, effective resistance within ±5 ohms, and the power calculated. 18 C_0 cancellation inductances and 1 uncompensated var. resistor supplied; 5 compensated var. resistors available. 115/230 v, 50-1000 cps.

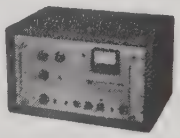
POWER SUPPLIES



Model 500

MODEL 500 is a single phase, 500 VA supply with choice of 4 plug-in osc. for combinations of variable output power, frequency and voltage. Has high stability, low harmonic distortion and excellent voltage regulation. Output frequency range 40-3000 cps; output voltage 0-130; harmonic distortion better than 0.5% at 200 VA to less than 1% at 450 VA; amplitude regulation 0.5% for 5% line kick.

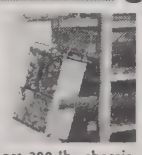
Model 150



MODEL 150 is a stable, 1 phase, 150 VA supply with choice of LC regulating osc. producing output frequencies from 380-2400 cps at 115 volts or a precision 400 cps ±0.01% osc.

SPECIAL HARDWARE

Chassis Slides H-5798



Will support 200-lb. chassis, quickly removable by pulling two pins. Complies w/ MIL Specs; has Iridite on cadmium plated steel rails, bronze rollers, stainless steel pins, nylon bushing. Price according to quantity ordered.

Sealnuts

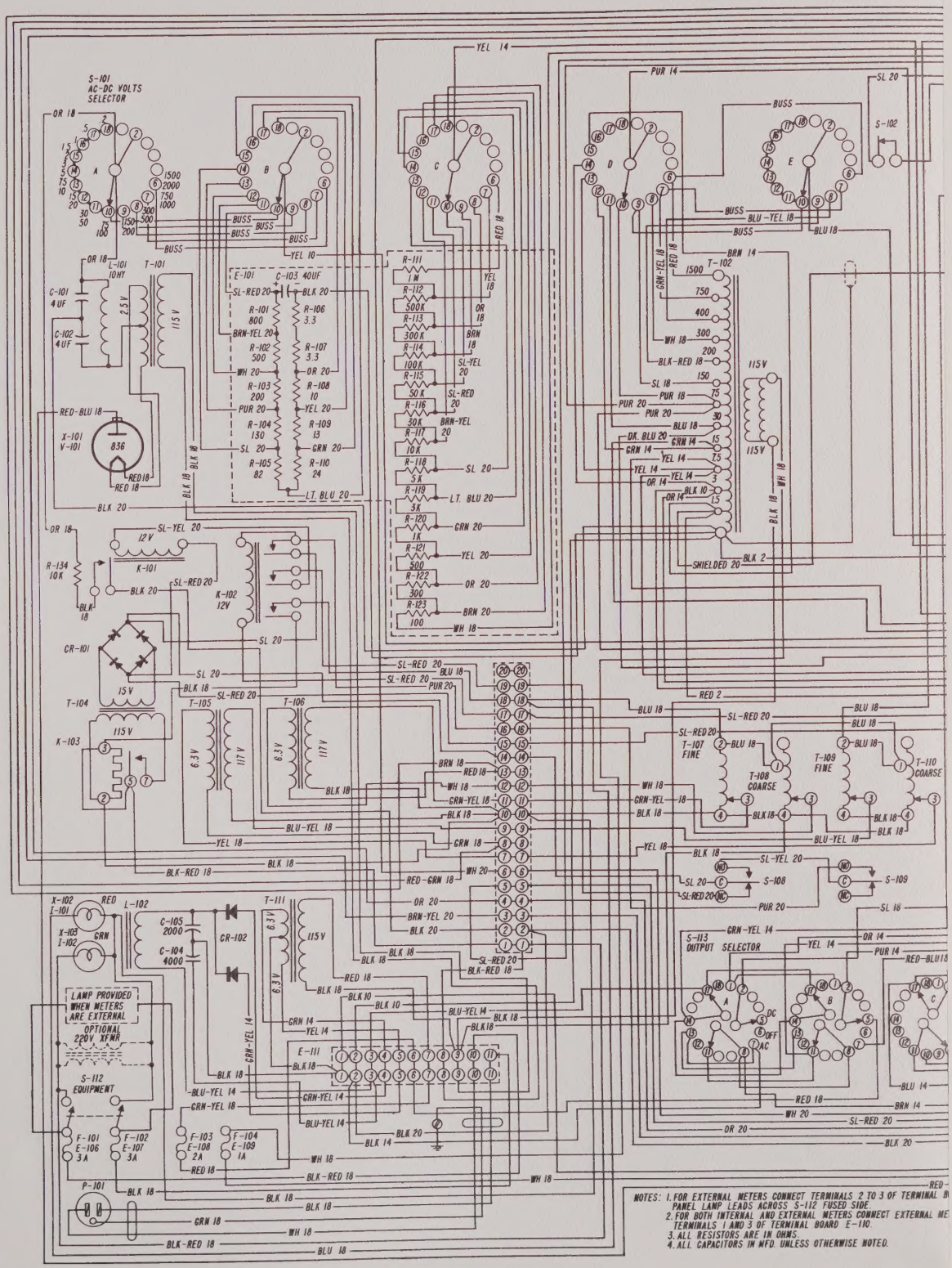
Seal out Water, Dirt & Corrosion

Mount and seal electrical switches. Eleven styles fit most toggle, rotary and push-button types; provide metal-to-metal contact w/panel; Silicone sleeve and O-ring seal against 200 psi ext.; stay flexible at —65°C; comply w/MIL-B-5423.

Model 10 Cart

Inside shelf adjusts any vert. position for 2-level support of equipment; interior is 33 x 16½ x 26. One side takes 19" panels per RETMA standards. Heavy gauge steel w/baked enamel over prime coat. Acc. drop-leaf shelf fits either side.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.


S-101 AC-DC VOLTS SELECTOR
T-101
T-102
T-103
T-104
T-105
T-106
T-107 FINE
T-108 COARSE
T-109 FINE
T-110 COARSE
T-111
S-102
S-108
S-109
S-112 EQUIPMENT
S-113 OUTPUT SELECTOR
LAMP PROVIDED WHEN METERS ARE EXTERNAL
OPTIONAL 220V XFMR
CR-101
CR-102
P-101
X-101 V-101 836
X-102 I-101
X-103 I-102
L-101 10HY
L-102
C-101 4 UF
C-102 4 UF
C-103 40UF
C-104 4000
C-105 2000
E-101
E-111
F-101 E-106 3A
F-102 E-107 3A
F-103 E-108 2A
F-104 E-109 1A
K-101 12V
K-102 12V
R-101 800
R-102 500
R-103 200
R-104 130
R-105 82
R-106 3.3
R-107 3.3
R-108 10
R-109 13
R-110 24
R-111 1M
R-112 500K
R-113 300K
R-114 100K
R-115 50K
R-116 30K
R-117 10K
R-118 5K
R-119 3K
R-120 1K
R-121 500
R-122 300
R-123 100
R-134 10K
115V
12V
6.3V
117V
2.5V
15V
BUSS
SHIELDED 20
NOTES: 1. FOR EXTERNAL METERS CONNECT TERMINALS 2 TO 3 OF TERMINAL BO
PANEL LAMP LEADS ACROSS S-112 FUSED SIDE.
2. FOR BOTH INTERNAL AND EXTERNAL METERS CONNECT EXTERNAL ME
TERMINALS 1 AND 3 OF TERMINAL BOARD E-110.
3. ALL RESISTORS ARE IN OHMS.
4. ALL CAPACITORS IN MFD. UNLESS OTHERWISE NOTED.

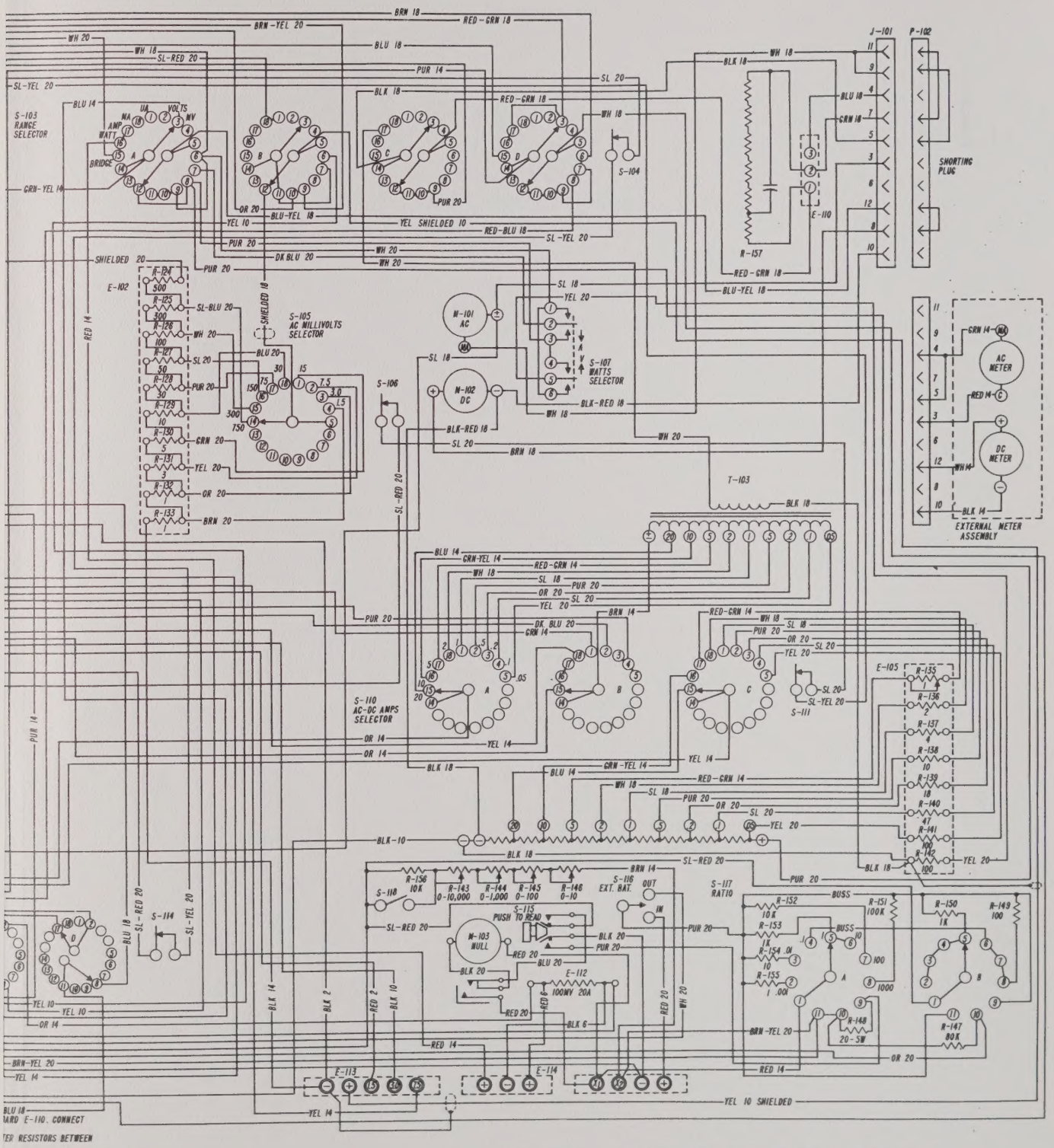


Figure 16. Schematic Diagram of Model 829/829A AC-DC Instrument Calibration Equipment.

STEP-BY-STEP PROCEDURE
FOR CALIBRATION OF INDUCTIVE AC MILLIAMMETERS

For AC milliampere calibration the decade resistance is connected in series with the AC milliammeter under test and standard voltage source. Then enough decade resistance (white knobs) is added to the AC resistance of the instrument under test so as to make the circuit have a total impedance of 10,000 ohms. When using 10,000 ohms as reference impedance, the standard voltages needed for the various milliampere ranges covered by the equipment will be as indicated in table below.

CURRENT	1.5 MA	3 MA	7.5 MA	15 MA	30 MA
VOLTAGE	15	30	75	150	300

To set the decade resistance properly so as to give an impedance of 10,000 ohms when in series with the instrument under test, the reactance (X_m) and the AC resistance (R_{mac}) of the AC instrument under test at the desired frequency must be known. An inductance bridge will readily give both X_m and R_{mac} values. The AC instrument will be inductive throughout the frequency range specified by the instrument manufacturer, and the AC resistance of the instrument will be approximately equal to the DC resistance of the meter winding, provided the instrument is used within the frequency range specified by the manufacturer. Frequency range is usually stamped on the face of the meter. DC resistance of the instrument winding will usually be found on the face of the meter, but check accuracy of value before calibration.

Next, if the meter X_m is found less than 400 ohms, decade resistance is found by subtracting either the AC or DC resistance of the meter from 10,000 ohms. The difference equals decade resistance setting. If, on the other hand, instrument X_m is found to be 400 ohms or greater, refer to the table of X_m and R_t values (shown in tabulation on reverse side). Then find X_m of the meter (or X_m closest to it) and note its corresponding R_t value. Then subtract the instrument AC or DC resistance value from R_t. The difference equals decade resistance setting.

In the event an inductance bridge is not available, another convenient method for arriving at X_m is by means of the instrument impedance (Z_m) whose magnitude can easily be measured by means of a variable resistance in series with the AC instrument under test and the voltage source at the frequency desired for calibration. Resistance is varied until voltage developed across it is exactly equal to the voltage across the AC instrument under test. Resistance needed for equal voltages will equal AC instrument Z_m. Once Z_m is found, use adjacent chart to find X_m and then Rd setting of the decade resistance.

HOW TO USE CHART
IN CONJUNCTION WITH THE TABLE OF X_m AND R_t VALUES

(1) Find on the horizontal scale R_{mac} or the DC resistance of the AC instrument under test.

(2) Strike a vertical line from the R_{mac} or DC resistance value until it intersects the impedance (Z_m) of the AC instrument under test.

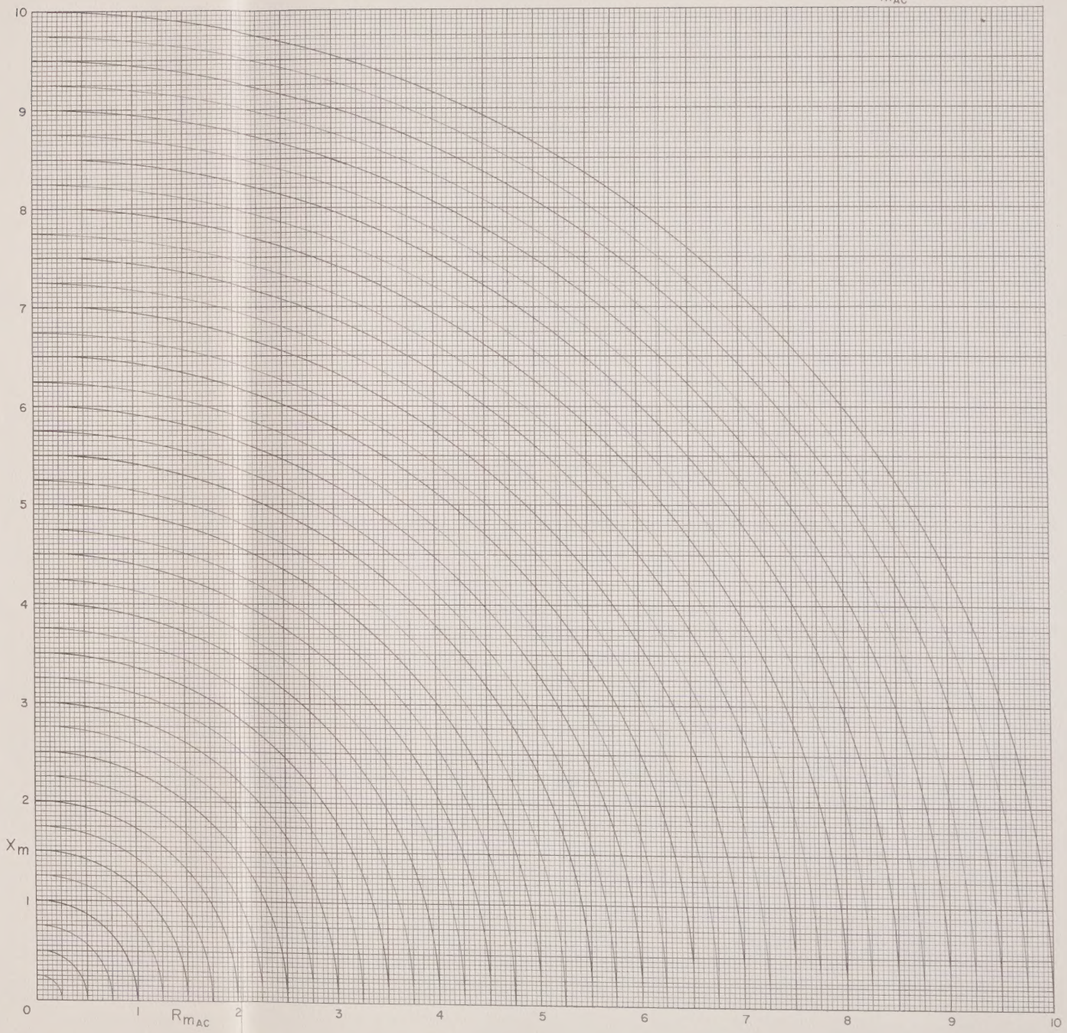
(3) At point of Z_m and R_{mac} or DC resistance intersection, strike a horizontal line to the left until it meets an X_m value on the vertical scale.

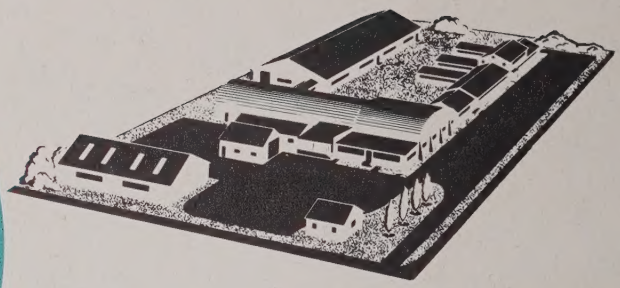
(4) Refer to the table of X_m and Rt values and find X_m (or closest value to it) and its corresponding R_t value.

R_{mac} Chart for use in setting the decade resistance in the calibration of inductive AC milliammeter 1.5 to 30 ma.

SERIES IMPEDANCE CHART

X_m = SERIES REACTANCE
R_{mAC} = A.C. RESISTANCE





Warranty

The Models 829 and 829A Instrument Calibration Standards carry a warranty of 12 months from date of delivery for replacement of any part, except tubes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f. o. b. Boonton, N. J.

Radio Frequency Laboratories, Inc.
BOONTON, NEW JERSEY, U.S.A.

Manufacturers of

MAGNET CHARGERS

TELEMETERS

TELEGRAPH TERMINALS

INSTRUMENT CALIBRATION STANDARDS

CRYSTAL IMPEDANCE METERS

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

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